



REPLY,

BY

MAJOR-GENERAL SIR ARTHUR COTTON,

TO

COLONEL SIR PROBLY CAUTLEYS

“DISQUISITION”

ON

THE GANGES CANAL.

LONDON:

PRINTED FOR PRIVATE CIRCULATION.*

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REPORT
ON THE
RAJMAHL CANAL.

1. Careful examination of the several reports, topographical surveys, and levelling sections, relating to the districts situated on the western side of the Delta of Bengal, prepared with a view to ascertaining the practicability of forming a permanent line of inland navigation between the Ganges at Rajmahl, and the Hooghly at Mirzapore, has appeared to the Committee to establish the following conclusions :

1st. That the *formation* of such a work would not be difficult.

2dly. That its *preservation*, in a state adapting it for being conveniently navigated at all seasons, by vessels drawing 5 feet water, could be insured.

3dly. That considering the extent of the work, and the great benefits derivable from it, the expense of its construction would be moderate.

2. Believing it to be generally admitted, "that opening and perfecting lines of interior communication," (more especially those leading from Capitals, having by sea, unlimited commercial intercourse,) has ever been found

eminently conducive to national improvement, it is deemed unnecessary to offer proof of the assertion, further than by referring to the prosperous state of Britain and America, where such works abound and are multiplying, compared with that of any country, however superior in natural fertility, in which they have continued neglected, or are unknown.

3. Bearing in mind that the Ganges receives, in its course through 1,200 miles of the central and infinitely improvable plains it fertilizes, eleven rivers, "several of them equal to the Rhine, few less than the Thames," and that when it has reached the head of the Delta at Rajmahl, its *distance from Calcutta* does not exceed 200 miles; and further having in remembrance, that during a great portion of the year, the only *passable* channel for boats drawing 5 feet water between the latter *City* (the Capital of India) and the station named, makes a circuit of 528 miles, (this chiefly through the perilous labyrinth of creeks and wood-encumbered straits, forming the wilderness called the Sunderbunds), it will readily be acknowledged, that amongst the good effects of opening a direct line of permanent navigation* between deep water in the Hooghly above Calcutta, and the great river at Rajmahl, there would be the highly important one of its affording the means of conveying safely, cheaply, and speedily to the Ocean outlet, *increased quantities*, and ultimately improved qualities of the agricultural and mineral produce of the entire regions traversed; nor this alone, as by inevitable commercial reciprocation, the same line would immediately serve for supplying these regions with augmented amounts of the sea-borne products or manufactures of other countries.

* Also answering for irrigation.

4. Such admission being assumed, the attempt to estimate the financial advantages likely to arise from the *undertaking* may conveniently be postponed, until an abstract has been given of the grounds on which *it* has been deemed practicable, and until some explanation has been presented of the plan, which facts and measurements have pointed out as best adapted for its accomplishment.

5. Upwards of 30 years have elapsed since the late Mr. Telford noticed the possibility of uniting “the upper parts of the Nerbudda with a *branch of the Jumna* ;” and since he asserted that, “besides intersecting the adjacent plains, the *branches of the Indus* might be connected with *those of the Ganges*, and an inland navigation opened between the confines of Persia in the West and those of China in the East.” Now remote as may be the contingencies admitting of the realization of these bold speculations, it is certain that they could not but be accelerated by *previously opening the line about to be described*, and which, if the greater undertakings were effected, would have its value inestimably enhanced by forming (through the Hooghly and Port of Calcutta) the sole channel of convenient communication between the Bay of Bengal, and the body of the Ganges, then constituting the “main trunk” of the mighty line of inland navigation contemplated.

6. Between permanent *deep water in the Mirzapore Creek, or Curree Nullah*, (2 miles, 1 furlong, and 230 feet,) *above its entrance to the River Hooghly*, and the rock-bound and unchangeable bank of the Ganges at Rajmahal, the distance by the intermediate line of Canal laid down on the accompanying surveys, is 129 miles, 1 furlong and 200 feet.

7. The total water surface fall in this distance, either by this line, or by the shoaly bed of the Bhaugiruttee river (which between the same points makes a circuitous course of 190 miles, in a direction generally parallel and nearly north and south) is 53 feet 5 inches.

8. Making the bottom of the Canal, at its head at Rajmahl, a depth of 6 feet below the lowest or dry season water surface of the Ganges, and giving it a fall of little more than an inch in the mile (in reality of 6 feet in 360930 feet, which is at the rate of 1.053 inches in a mile) the entire slope or fall of the bottom in the total distance from the Ganges to the Curree Nullah, 129 miles, 1 furlong and 200 feet (equal to 681980 feet) would be 11.337* feet; which deducted from 53 feet 5 inches (or feet 53.4166) the total water surface, difference of level at Rajmahl and at the Nullah at Mirzapore, leaves a descent of feet 42.0796 to be provided for by intermediate lockage.

9. With this fall, or slope, the BOTTOM of the Canal will be precisely on a level with THAT of the bed of the Dwarka River at the spot where the latter will have to be crossed, that is, at a distance from Rajmahl of 68 miles, 2 furlongs and 570 feet—(this being equal to the 360930 feet that for the general slope of the bottom of the Canal was made the basis of the preceding calculation.)

10. Thus sloped the bottom of the Canal will be 5.9901† feet above that of the bed of the Bansli, at the most convenient point for its being crossed, 39 miles and 200 feet to the southward of Rajmahl, and at a distance from this

* See page 150 of Calculations.

† See page 92 of Calculations.

station, or from the Ganges, of 84 miles, 1 furlong, and 130 feet, the bottom of the Canal at the point of crossing, *below the junction of the More and Queea Rivers*, will be feet 2.114 above that of their *united bed*. At the crossing of the Adjì River, 111 miles, 6 furlongs, and 520 feet from Rajmahl, the bottom of the Canal (intermediately lowered by a regulating lock, having a fall of feet 3.0605,)* will be precisely on a level with that of the bottom of the bed of the Adjì.

11. Here attention being given to the fact, that during nearly *half the year*, the beds of these streams, forming the principal water drainage channels of the country the Canal would intersect, are nearly *empty*; it will be obvious that, to retain, during the dry season of the year, a depth of 6 feet of water in the Canal, it would be requisite that their beds should be crossed (in a direction parallel to that of the Canal) by dams of the following heights :

	<i>Feet water in Canal.</i>	<i>Feet heights of dam.</i>
†1st. The Bansli by a dam,...	5.9901	+ 6 = 11.9901 feet.
‡2d. The Dwarka by a dam,	0	+ 6 = 6. feet.
§3d. The united More and } Queea by a dam, ... }	2.114	+ 6 = 8.114 feet
¶4th. The Adjì by a dam, ...	0	+ 6 = 6. feet.

12. Supposing dams of these heights formed at the respective crossings, and that these dams contained sluices opening down to the bottoms of the river beds or channels crossed, it will easily be understood, that the setting

* See page 150 of Calculations.

† See page 92 of Calculations.

‡ See paragraph 9.

§ See page 145 of Calculations.

¶ See latter part of paragraph 16.

open of one or more of these sluices (commencing with those of the dam nearest Rajmahl) would, *even at the dryest season of the year*, occasion in successive portions of the Canal such currents as *unlimitedly* fed by water entering from the Ganges, would have the effect of clearing out from the bottom of the Canal any possible alluvial deposit.

In illustration of this point, let it be supposed, that the depth of water in the Canal was (as it would be in the dry-season) 6 feet, and that at the same time the depth of water in the (nearly empty) bed of the Dwarka River, below the dam was 6 inches, it will be perceived, that if under these circumstances a sluice in the dam, say 6 feet wide, and extending down to the bottom of the river bed was opened, the water in the Canal having its surface elevated $5\frac{1}{2}$ feet above that of the river below the dam, would flow out with the velocity incident to such a head; and the calculation for the discharge through such a sluice or opening ($6 + 5\frac{1}{2}$ feet) being made, it will be found that, aided by the slope in the bottom of the Canal, the quantity discharged in an hour would be 2,138,400* cubic feet.

Here noting, that the Canal, with a depth of 6 feet water, and having a breadth at bottom of 50 feet, and side slopes of $1\frac{1}{2}$ horizontal to 1 perpendicular, would have a minimum section of 354 square feet† open to the Ganges, and that the proposed bottom slope of 1.053 inch. in a mile, would (when all the dam sluices were closed) only make the velocity of the descending current 3,046‡ feet, or 4 furlongs and 406 feet (little above half a mile) in an hour, it will (by multiplying the area of the section 354 by the velocity 3,046) be discovered, that the

* See page 10, 1st copy.

† $59 \times 6 = 354$.

‡ See pages 158 and 15 of Calculations.

quantity of water *received in the Canal in an hour*, would merely be 1,178,284* cubic feet.

Now as this is an amount not much exceeding half of that which it has been ascertained would be discharged by one such sluice as has been described, viz. 2,138,400 *cubic feet per hour*, it will be obvious that this comparatively great discharge would speedily have the effect of lowering the surface of the Canal in the vicinity of the sluice, and consequently that of setting in motion a current between it and the Ganges which, necessarily, would increase in velocity until the supply received at Rajmahl equalled the discharge by the sluice. From which it cannot but be inferred that by successively opening *one or more such sluices* in each dam, any velocity that could possibly be required for *preventing alluvial deposits or for removing them if formed*, could be insured.

It indeed may be mentioned that as, when this equality of supply and of discharge had taken place, the mean velocity of the intermediate current, would be 6,040† feet (or 1 mile, 1 furlong and 100 feet *per hour*), and that as this velocity is at the rate of 20.112 *inches per second*, while it is known that on a smooth *level* bottom a velocity of 12 *inches per second* is sufficient‡ “to lift and set in motion fine gravel,” it becomes certain that by opening in the order of their succession from Rajmahl, merely *one such sluice in each dam*, there would, even at the driest season, be established an amply efficient scouring current from end to end of the Canal.

* See page 11, 1st copy.

† $\frac{2,138,400}{354} = 6,040$.

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‡ Page 695 Appendix of Telford's Memoranda, and Brewster's article Hydrodynamics.

13. It remains to be explained that by placing (as is proposed) in each of the four dams a set of SLUICES of the dimensions stated, so constructed as constantly to remain open, with their edges presented to the current of the river crossed, when the depth of water in the Canal exceeded 6 FEET 3 INCHES, such a thorough scour would be caused through THESE, and consequently through the intervening reaches of the Canal, during the period they continued unclosed (probably 5 months in the year) as would seldom (if ever) render it necessary they should be opened for a similar purpose in the dry season.

14. In fact bearing in mind that during the *dry season* alone, the fall of *rain* water amounts to 28 inches, and that as the Canal would partly serve as a reservoir or catch-water drain for the country to the westward, its surface would occasionally be raised by portions of this fall (occurring at intervals) more than 3 INCHES, therefore more than a sufficient height to open such self-acting sluices, it will be seen, that the process of scouring (always incident to their being opened, and ever accompanied by an increased current from the Ganges) would, even in the dry season, intermittingly, but inevitably, take place.

15. It moreover is not unworthy of consideration that were these sluices formed so as not to be perfectly water-tight, the only effect of their leakage would be that of constantly keeping up a *current* from the Ganges, through the Canal, of *itself beneficial in scouring*.

16. By means of such sluices, and of "stop-gates" placed in the reaches situated between the dams, it will be evident that *during the dry season (or half of the year)* any part of the bottom of the Canal could be laid dry, either for the purpose of deepening it (if ever found requisite) or for the

repair of the few works rendering it a line of permanently navigable communication.

17. By closing at the season alluded to, a pair of those "stop-gates," the water in the Canal on the upper or Raj-mahl side of them would necessarily *be raised, until*, abreast of the nearest dam above, it had acquired the depth of 6 feet 3 inches, or the additional head of 3 inches, rendered by the form of the sluices sufficient for setting them open; but as it has already been explained that their being in any way opened would have the effect of establishing a scouring current through the portion of the line lying between them and the Ganges, it will be seen that one of various convenient modes of opening *the set of sluices* in any particular DAM would be by closing *across* the bed of the Canal the pair of stop-gates immediately below it.

18. To revert, however, to the preceding case, it will be perceived that if in the dry season, a pair of stop-gates had been closed while the sluices of the nearest dam below had been opened, so as either partly or entirely to lay dry the adjacent subdivision of the Canal, the drawing up of the paddle boards of the stop-gates, (then having against them a head of water 7 or 8 feet high,) would necessarily cause a scouring current *directly along the line of the Canal*, as powerful as could safely be employed, or could ever by any possibility be required.

19. Finally, on this point, it may be remarked that nearly the same effect as would be insured by the *permanent construction* of the stop-gates, would be obtained by the *gradual removal* of a small bund or embankment, of the same height as the stop-gates, TEMPORARILY formed across the Canal.

20. Having thus ascertained that were the communication formed on the line, and in the manner indicated, there would readily be available ample means of keeping it

permanently navigable, it remains to be shown that the facilities afforded by the soil to be cut through, and by the localities generally, for the construction of the requisite works, are greater than had been anticipated.

21. When the first general survey was commenced,* it was imagined that the levels of the country were such as would have made it necessary to have carried the Canal in a circuitous course to the westward, where it would have crossed the hill streams *by aqueducts* situated near to the hills, consequently in sites where during part of the rainy season their currents (then contained between the banks of very broad channels, having rapid descents) would have had such great velocity as to have rendered the construction of these works (there necessarily consisting of piers of considerable height) *exceedingly expensive*.

It is now however proved, by the completed topographical survey, and by a series of accurate *longitudinal and transverse* sections (extending upwards of 1,000 miles) that on entering the plains to the eastward, (but still to the westward of the Delta of the Ganges,) the various streams alluded to become united, so as to admit of the Canal being conducted across them by the *four low dams*, partly described in the 11th and following paragraphs.

✓ 22. The same sets of plans,† and the reports which accompany them, also combine to prove that the average length of these dams may safely be made less than half of that which it would have been necessary to have given to the high western aqueducts, and consequently, that not merely the greater part of the expense of these larger works may be avoided, but moreover, *that* of huge embankments, which, near most of their sites, would have been

* In the year 1831 or 12 years after the Canal was proposed by Lieutenant Forbes.

† Plans occupying 60 large sheets of drawing paper, exclusive of 150 square feet containing the topographical survey.

required for raising the Canal to what there would have been their comparatively greatly elevated level.

23. On these points, the final report of Lieutenant Cunningham states, "a further examination of the plans
"and sections will show that, with the Ganges as a feeder,
"and by pursuing a line nearly direct, the Canal will
"intersect the Bansli after it has been joined by the
"Pogla, the Dwarka after it has been joined by the
"Bimmaney, and the More below the present junction
"of the Queea. It will moreover intersect (in these and
"in the Adji) all the hill streams where their channels
"may be said to be *permanent* ; where they have lost the
"violence of mountain torrents, and become *when highest*
"SLOW MOVING INUNDATIONS ; and lastly, it will intersect
"them at points where their beds are very little lower
"than the bottom of the Canal, AND WHERE DAMS ONLY,
"and not AQUEDUCTS, will be required."

24. One of the circumstances here alluded to, viz. that of the currents of the hill streams being converted into SLOW MOVING INUNDATIONS where the Canal on the line finally proposed would cross them, it may be well to explain would be attributable to their being met in the vicinity of the lower crossing points by the wide spreading inundation of the Bhaugiruttee River, which having its tortuous course generally parallel to the line of the Canal, consequently at right angles to the direction of the *easterly* flowing hill streams, would partly act as a dam in making the water brought down by them, stand back *almost without motion* in their beds, and on the extensive low lands adjoining their banks.

25. By the joint inundation thus produced in the vicinity of the rivers which would be intersected, it will be observed, that the four dams requiring to be formed in their bottoms for insuring in the dry season a depth of 6 feet of

water in the Canal, would, to a considerable depth, be overflowed; but as the sluices of these dams would, from the form given to them, necessarily then remain open, and as it is proposed that the dams should entirely consist of a series of sluices placed (between strong cast iron blades, or piers) so as only to close when the depth of water in the Canal falls to 6 feet, it will be seen that to insure to any one of the "slow moving" currents of these four rivers as free a water section as it at present has, it would only be necessary to *avoid* embanking the Canal across the lands adjoining a river bed, and now at the height of the inundation overflowed, and to increase the section of the channel containing the "slow moving" current, and the low dam, at the site of the latter, as much as would compensate for the *inconsiderable retardation* that would be occasioned to such a current by the edges presented to it of the opened sluices, and by the sloping ends of the iron blades constituting the intermediate sluice piers.

26. Under the circumstances adverted to, or at the utmost known heights of the inundations, the water in the Canal would stand 22.426 feet above the piers of the Bansli dam, 16 feet above those of the Dwarka dam, 17.386 above those of the More and Queea dam, and 13 feet above those of the Adji dam.

The *utmost* depth of water in the Canal would then be* at the head at Rajmahl 40.5 feet, at the Bansli dam 28.426 feet, at the Dwarka dam 22 feet, at the More and Queea dam 23.386 feet, and at the Adji dam 19 feet. Were the Canal embanked on both sides (excepting in the vicinity of the dams) above the level of inundation, the utmost superficial velocity of the current entering it, (when the depths were as above stated,) from the Ganges, and flowing off with the nearly motionless inundation of the *Bansli*, where it would be intersected, could not exceed

* On an average of years only 28 feet.

2 miles, 3 furlongs and 480 feet IN AN HOUR.* Between the inundation of the Bansli and that of the Dwarka, the utmost superficial velocity of the current in the Canal, during the inundation, would be 1 mile, 7 furlongs per hour.† From the Dwarka to the united More and Queea, there would then in the Canal be no current, in as much as their inundations communicate freely, and consequently have the same level. The extreme superficial velocity of the current in the Canal between the More or Queea, and the Adji, during the inundation, could not be greater than 2 miles, 2 furlongs and 309 feet per hour;‡ but as these rivers are occasionally not at the same periods, in a state of inundation, one of the locks proposed to be employed would be situated between them, at the commencement (to the northward of the Adji) of the firm [unalluvial] intervening ridge of land, where, acting as a regulating lock, it could be made to modify the current as found expedient, and where, when the general inundation was subsiding, it could be rendered instrumental in scouring the adjacent reaches of the Canal.

The utmost possible superficial velocity of the current in the Canal between the Adji, and a lock situated 35,560 feet from the lower end of the Canal, would be 2 miles, § 1 furlong and 594 feet per hour, and above this lock, the water not required for the use of the Canal, would freely overflow into the wide low level of the inundated Curree Nullah, communicating with the Hooghly River.

27. The difference of level between the bottom of the Adji where crossed by the Canal, and the bottom of the

* See page 171 of Calculations, where it is estimated according to the Rule given in page 200 of Dr. Young's "Summary of Eytelwein's Hydraulics"—edited by Thomas Tredgold (the 2d Edition published in 1836.)

† See page 164 of Calculations.

‡ See page 166 of Calculations.

§ See page 168 of Calculations.

Curree Nullah where the water in it (at the lower end of the Canal) is 6 feet deep, is 42 feet,* the intermediate distance is 144,420 feet, (or 27 miles, 2 furlongs and 340 feet,) and if between these points, the Canal were cut with one uniform slope, or so as not to employ locks, the velocity of the current in the dry season, when the least depth of water in the Canal would be 6 feet, would be 11,880 feet† (or 2 miles and 2 furlongs) PER HOUR, and with this velocity, and depth, the discharge into the Curree Nullah, or into the adjacent Hooghly River, would be 4,205,520 cubic feet of water per hour,‡ but as the *Canal* from the Adji to its head at Rajmahl can only have a bottom slope of 1.053§ inches in a mile, which at the same season, with a depth of 6 feet, would but admit of the current entering from the Ganges, having a velocity of 3,046|| feet (or 4 furlongs and 406 feet) per hour, the total admission of water *from the Ganges* could then only be 1,078,284 cubic feet per hour, and it hence becomes apparent that unless the water brought into the Canal, during the dry season, by the Adji, More, Dwarka, and Bansli Rivers, could be depended on for *regularly* supplying the difference, $(42,05,520 - 10,78,284) = 3,127,230¶$ cubic feet per hour, which (being then *occasionally* almost empty) could not safely be calculated on, the depth of water in the Canal would, certainly, at this season, get reduced *below 6 feet*, and as this could not be permitted, it becomes obvious that the introduction of the lockage** adverted to in the preceding 8th paragraph, would be indispensable.

* Making the fall per mile 18.2 inches.

† See page 175 of Calculations.

‡ See page 177 of Calculations.

§ See paragraph 8.

|| See pages 144 and 157-8 of Calculations.

¶ See page 177 of Calculations.

** 4 locks, which, with the 2 previously mentioned, would make the total number of locks 6; the number of dams being but 4.

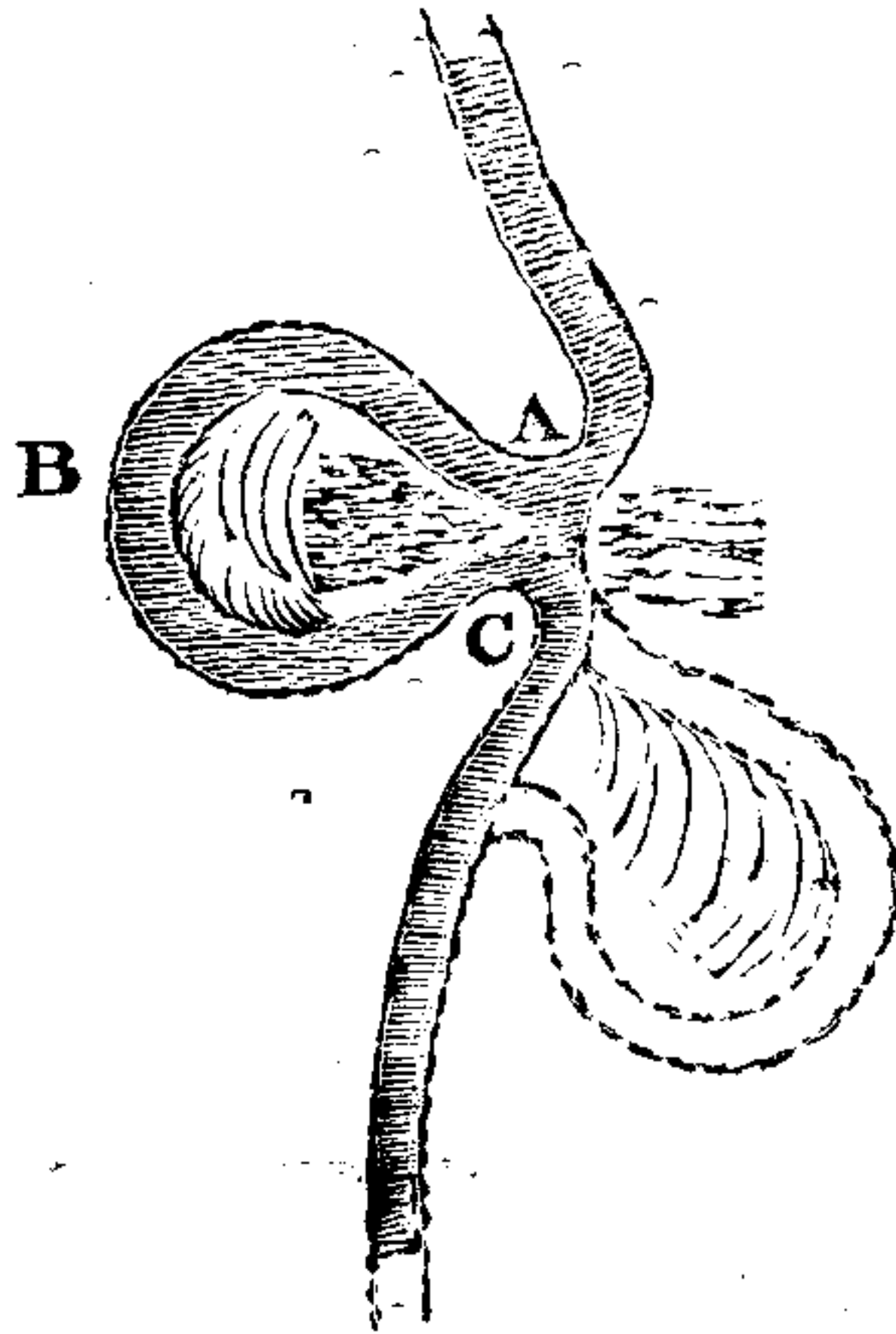
28. The circumstances stated, also show, that if an attempt was made to rectify the exceedingly tortuous course of the *Bhaugirruttee River*, between the mouth of the *Adji River* at *Cutwa*, and the mouth of the *Curree Nullah* at *Mirzapore*, (or the lower end of the Canal in the *Hooghly*), by cutting through the narrow necks of the intervening loops or horse-shoe bends, the immediate effect of such rectification would be its laying nearly dry for several months in the year the bed of the *Bhaugirruttee* between the *Adji* and the shoals periodically formed in the former River near its exit from the *Ganges*; yet such rectification of the *Bhaugirruttee* has not infrequently been proposed as the means of improving its navigation; and were the Canal levelling sections of no other value, they would be useful in demonstrating that an outlay of money on attempts, by such cuttings, to improve the communication through the bed of the *Bhaugirruttee*, could only terminate in making it (if possible) worse.

29. The comparatively great difference of level between the *Bhaugirruttee* at *Cutwa*, and (its continuation,) the *Hooghly* at *Mirzapore*, being in the direct line of its present course at the rate of 7.2652* inches in a mile, also explains the great tortuosity of its intermediate bed, and the cause of its constant shallowness in the dry season; as, running through the soft and sandy alluvial soil of the *Delta* of the *Ganges*, (which the Canal does not,) such soil could not possibly bear the abrasion and under-cutting incident to a current of 6 miles per hour, which it at least would be, during the inundation season, if the lower third of the course of the *Bhaugirruttee* were straightened so as to make its fall (what in a direct line it actually is) 7.2652 inches per mile.

* See page 188 of Calculations, also Lieutenant Cunningham's Table of the fall of the *Ganges* "and *Bhaugirruttee*," Division 3d of his Report.

In such a soil, with such a velocity, the channel, in place of continuing straight, necessarily acquires the serpentine curves, and circumflexions, which the accompanying Map of it represents, and which, by reducing the fall, in its crooked course, to $3\frac{1}{2}$ inches per mile, enables the banks, for a time, or until the neck of one of the loops is cut through, to bear the reduced current, but as the immediate effect of this natural rectification is an increase of fall per mile in the bed adjacent,* and consequently a great local increase of velocity, it is invariably found that each such event precedes, and occasions, the formation of a similar horse-shoe-bend, pointing in an opposite direction, in the thus everchanging natural channel.

* Suppose the bend. A B C to be 10 miles in length,



And to have a fall from A to B, and B to C, at the rate of $3\frac{1}{2}$ inches in a mile, and that the cut A C being one mile in length, is formed, it is evident that the total fall in this cut, of one mile, will be $3\frac{1}{2}$ inches \times 10 = 35 inches, or nearly 3 feet, and consequently that the velocity of the current passing through it, will be so increased as to produce the effects described.

30. As the above description applies generally to the northern portions of the Rivers of the Sunderbunds, or to those of the Delta of the Ganges, not directly and powerfully influenced by the tides of the head of the

Bay of Bengal, the slightest *inspection* of any tolerable Map showing the present course of these rivers to the southward from the Ganges, and the numerous intermediate jheels, or stagnant pools, which at one time formed portions of their channels, will prove that an alluvial region which has been so traversed over by these streams, and which is still as much as ever subject to being again traversed by them, is as badly as possible adapted for the site of a *permanent* line of water communication from the Hooghly above Calcutta to one of the easterly Sunderbund streams leading to the Ganges. Yet within the last few years, the opening of such a line, crossing by locks, and loose brick dams, large and deep rivers, constantly liable to the changes that have been adverted to, has been seriously proposed. Nor so situated and constructed could there be but two objections to undertaking such a work, the one, that from the nature of the dams proposed, it would be nearly empty in the dry season, the other, that from the peculiar construction of the locks exhibited, it would in the season of inundation be impassable. The latter objection might apparently have been got rid of by leaving the *locks open* during *this* season, but being useless in the dry months, this would have been tantamount to totally omitting them from the plan, a measure that (as *correctly* affirmed by its inventor) would have led to another extraordinary inconvenience, namely, the speedy filling up of the very deep (and consequently very costly) channel proposed to be excavated by alluvion thrown into it by the inconstant, and ungovernable, rivers crossed. The million-horse power of those Sunderbund Rivers cannot be trifled with, by brick dams, &c., but even had other dams of solid stone masonry, or such as would have had a chance of resisting the force of their currents, been proposed, it is sufficiently evident, that their only effect would have been to make the streams (as is their habit)

form for themselves new and comparatively unobstructed channels.

31. The Committee appointed in 1831, to report "whether there be any and what prospect of keeping the Bhaugirruttee River open, or, of ESSENTIALLY improving the navigation of it by any means at the disposal of Government," after arriving at the conclusion that there *was not*, and that the certain result of forming a cross channel between one of its upper reaches and the Ganges, would be the early filling up of this channel by shoals of alluvion, similar to those annually deposited in the Bhaugirruttee itself, recommended the construction of the Rajmahal Canal, or of the one immediately under consideration, expressly, on the ground that "no cut running nearly east and west, therefore generally at right angles to the main discharging branches of the Ganges, will ever be found PERMANENTLY favorable for navigation."

This Committee consisted of Colonel McLeod, and of Captain Forbes (Engineers) and of John S. May, Superintendent of the Nuddeah Rivers; and bearing in mind that the party last named was one of those who, on the GROUNDS alluded to, and on *others* stated in the Report, joined in urging on the attention of Government the superior facilities for permanent navigation that would be afforded by the Rajmahal line, it appears inexplicable how he could subsequently have fallen under the delusions which led to his proposing the line from the Hooghly to the Goroy, referred to in the preceding 30th paragraph; and which, running nearly "east and west across some of the main discharging branches of the Ganges," and being in consequence liable to the impracticabilities pointed out, would certainly be as unfavorable for "permanent navigation," as could well be imagined. *

32. As the Rajmahl Canal would skirt the western side of the Delta of the Ganges, and would there *generally* have its *site* on ground, which so far from being composed of Ganges alluvion, is probably coeval with the adjacent hills of which it forms the base, it will be perceived, that so situated, its line would have between it and the Ganges, the rocks at Rajmahl and at Oodwa Nullah, and that subsequently having a course nearly due south, therefore diverging from that of the Ganges, it would pass through the hard clay spurs or ridges, surmounted by rock, met with in the vicinity of the villages of Chunsur, Sookur Bassinee, Kendooa and Gugganpuharree, *ridges* which, although reached by the inundation of the *Ganges*, and consequently now superficially presenting its alluvion, would effectually serve (as they heretofore have done) to keep its channel in the sufficiently remote north-easterly direction it ever in this quarter has occupied. Further to the southward, the Canal would have interposed between it and the Bhaugirruttee River the high ridge and ranges of hard red clay terminating far to the southward and eastward at Rangamuttee, a village situated on the western bank of the Bhaugirruttee;—and southward of this village there would be interposed the comparatively low ridge separating the Queea and Bhaugirruttee Rivers, as well as the high, and never-inundated, ground lying to the westward of the Queea, between the village of Burrutpoor and the junction of the Queea with the Bhaugirruttee, $5\frac{1}{2}$ miles to the northward of Cutwa.

Having crossed the Adji nearly 4 miles to the westward of Cutwa, the Canal, keeping clear of the old channels of the Bhaugirruttee, would pass through the end of a ridge interposing between the Adji and Damooda Rivers, and would thence proceed until it reached the deep Curree Nullah, and the adjacent tide-influenced (therefore deep and changeless) channel of the Hooghly at *Mirzapore*.

33. The descent to the Curree Nullah would be effected by *four* contiguous locks, each *having a fall of 7.92 feet,** situated on its hard, but easily excavated, northern bank.

34. As the utmost velocity of the current entering the Canal from the Ganges during the greatest known height of the inundation would be (as mentioned in paragraph 26) only 2 miles, 3 furlongs and 480 feet, it has, (after much calculation, and after the consideration of all the contingencies which can be supposed to affect the question,) been concluded, that it would be perfectly safe, and in various ways, advantageous to dispense with the use of locks near the head of the Canal in the Ganges.

35. Such locks, if introduced, would in the dry season have had their gates to have been kept constantly open, and of consequence, they would then have been useless, and if it is supposed that, in the months of inundation, one lock (or two pairs of gates) were employed, it will be perceived, that if the water standing back from the Ganges below Rajmahl were allowed at the lowest levels freely to enter the *Canal* from the eastward, as for instance at the point where it crosses the Oodwa Nullah nearly 6 miles to the southward, the utmost difference of level of the Ganges above the upper pair of these gates could not (supposing the lower *pair* open) exceed the total fall in these 6 miles of the Ganges, and as the (surface) fall of the Ganges at this season, is but $3\frac{1}{8}$ † inches in a mile, it hence appears that this total fall in the 6 miles ($6 \text{ m.} \times 3\frac{1}{8}$ inches) could only amount to $18\frac{6}{8}$ inches. It thus will be seen that the only use of the lock alluded to would be to

* See page 151 of Calculations.

† See Lieutenant Cunningham's Table of the "Fall of the Ganges" and Bhaugirruttee from Rajmahl to the head of the Bhaugirruttee."

raise or lower the vessels passing through the *Canal*, during a few months of the year a height of $1\frac{1}{2}$ feet. But as it has already been mentioned that the velocity of the current entering the *Canal*, could not exceed $2\frac{1}{2}$ miles an hour, and as the entrance channel would be formed through rock and such soil as would not be injuriously affected by so moderate a *current*, it further is obvious that the retardation it would occasion to vessels *ascending*, would in reality be *less* (and in other respects less inconvenient) than that which would arise from making every vessel proceeding either upwards or downwards enter a lock only affected by such an inconsiderable difference of levels.

36. It may here be remarked that the same fall per mile as in the broad and deep channel of the Ganges causes a great velocity of current, would only in the *comparatively* narrow and contracted channel of the *Canal*, occasion the diminished one estimated above, according to the formula of Eytelwein.

37. By forming part of the earth excavated from the *Canal*, between its head and the base of the conical hill it passes near the village of Oodwa Nullah, into an embankment, rising on the western side of the *Canal* a little above the inundation of the Oodwa Nullah Jheels, there extending far to the northward and westward, the immense body of water contained in the reservoir thus formed might, either separately, or in combination with the sluices constituting the river crossing dams, be employed in scouring from the head, or from the reaches of the channel interposing between Rajmahl and the Bansli, such alluvial deposits as, when the annual inundation was subsiding, might temporarily be formed.

38. In place of a lock, a pair of stop-gates (such as have previously been described, but which need not exceed 12 feet in height from the bottom) might be placed

in the Canal in the hard low ridge of ground situated about a mile to the southward of Rajmahl, and which being closed, (when the inundation was running off,) whilst sluices communicating with the reservoir formed by the Oodwa Nullah Jheels were opened, would enable the entrance channel or head to be *scoured into the Ganges* by a current easily regulated to such a velocity as, for the purpose, might be required.

39. By similar means, or by reservoirs, filled during the season of inundation, any deposits formed in the Canal in the vicinity of its four river dams might be speedily removed, and as the powerful current afforded by these reservoirs would be *supplemental* to the scouring action insured throughout the line by the construction of the dams, and as with reference to the instrumentality of these last, (*constant* in the season of inundation and *occasional* in the dry months,) it is probable such additional aid would never be required, (this more especially when it is borne in mind that any portion of the line could temporarily be laid dry for the removal of deposits,) it is apparent that the construction of such reservoirs would be unnecessary, save in localities where they could readily and almost at no expense, have their embankments formed by the earth excavated from the Canal.

40. Having in view the historical detail given in Lieut. Cunningham's Reports of the changes which have taken place on the channel of the Ganges in the vicinity of Rajmahl,* and having regard to the circumstances affecting this point, stated in our former reports, we see no reason for apprehending that the branch of the river now flowing past the rocks, which would constitute the

* Once the Capital of Bengal.

bulwarks of the head of the Canal, will ever be left impassable for *vessels* drawing 5 feet of water, or for *such* as at all seasons could safely and speedily pass through the line of navigation proposed to be provided.

41. However far the *main body of the Ganges* may for a time have retired from these *rocks*, they appear always to have been skirted by a navigable stream *directly communicating with it*, and which must constantly be kept open (and if ever left a back water probably to a still greater depth) by the Nullahs fed by the springs met with, and the rains falling, on the range of hills situated between Rajmahl and Sicly-gully.

42. It may also be observed that through this channel, the entire body of water brought down by the *Oodwa Nullah*, added to that collected in the immense reservoir formed by the *Oodwa Nullah Jheels*, would, under the circumstances speculated on, the temporary retirement of the main body of the *Ganges* from these *rocks*, be discharged to the *Ganges* through the branch or channel continuing to flow round *them*, and into which channel during the dry season, or the only period at which it could by possibility be impeded, the whole contents of the reservoir could be admitted from under a head (or surface level) elevated 20 feet, and consequently with such a velocity as would insure its permanent navigability.

43. The highly favorable circumstances under which the lower end of the Canal would enter the Hooghly, in the vicinity of Mizapore, were generally explained in our previous reports, and have now, with reference to the accurately known levels, been fully detailed in the accompanying Reports prepared by Lieut. Cunningham.

44. The great extent of country drained by the Curree Nullah into the Hooghly, will certainly always

secure an ample depth of water in the short portion of the Nullah situated between the river and the 4 locks proposed to be formed on the high and hard ground on the northern bank of the Curree, and which, opening to the central reaches of the Canal by another lock, and by the regulating one situated on the ridge to the northward of the Adji, would, as regards this description of work, complete the communication between the Hooghly and the Ganges.

45. In summation of what has above been stated, it may be observed, that after the fullest consideration we have had it in our power to give to the plans and levelling sections, furnished by Lieutenant Cunningham, and to the mass of valuable information either contained in his Reports or embodied in the tables annexed to them, and further, that after having reviewed all the facts and circumstances previously ascertained relating to the subject, we have seen reason to conclude that by means of the 4 dams described, the 6 locks adverted to, the few stop-gates (for facilitating scouring) mentioned, and the Oodwa Nullah Jheel reservoir, and such other scouring reservoirs as could readily be formed on the western side of the Canal, the line of navigation proposed could certainly, at all seasons, be kept in a state adapting it for being navigated by vessels drawing 5 feet of water. We also may state, that the line having thus been formed, it will diminish the navigable distance from Calcutta to Rajmahl for the River Steamers, during the large portion of the year they are now obliged to pass round by the Sunderbund Channels, 326 miles.* It may moreover be noted that, as during the same period the same distance of 326 miles would be saved to nearly all the vessels and country craft employed in carrying

* The distance by the Sunderbund Channel is 528 miles, while that, 72½ miles by the Hooghly and 129½ by the Canal, only amounts to 202 miles, and $528 - 202 = 326$ miles.

passengers, produce, manufactures, military stores, troops, treasure, &c. between Calcutta and the Ganges, the effect, as concerns expeditious transit, of opening such a line, would in some measure be tantamount to that which would proceed from providing each and all of the descriptions of craft referred to with Steam Engine power.

46. During the season of inundation, such a direct and, comparatively, still water line of navigation would certainly be passed through by all classes of vessels *ascending* from Calcutta to the great river, inasmuch as by means of it, most of the time at this season lost in contending with the then rapid, and ever tortuous, *Bhaugirruttee*, would be avoided, as also the risk in the *latter*, annually leading to numerous wrecks, and to total losses of large amounts of property.

But independent of the number of deeply loaded craft that, with reference to the latter consideration, would at this season also *descend* by the Canal, it is obvious that during the large portion of the year, when for such vessels the Nuddeah Rivers are altogether impassable, it would necessarily be constantly resorted to by them.

47. Adapted as concerns lockage for conveniently passing 360 vessels (including Steamers) in a day, some of the circumstances adverted to in our former Reports, and amongst them the fact that at one time, when *two* of the *Nuddeah Rivers* were only passable for dinghees, (or the smallest description of country boats,) and that whilst at the same period* the third one was only navigable for the minor class of cargo boats, the annual collections in the form of Toll, at the rate of 1 Rupee per 100 maunds, on the total tonnage passing through these channels, amounted to 1,50,000 Rupees, assuredly prove, that if the comparatively safe and direct line by the Canal were once

* The dry season.

opened, and fairly established, the total amount of tonnage daily passing through it would not fall short of 3,000 tons; which (at 27 maunds to a ton) would make the *total number* of boats passed in a day (each averaging 600 maunds burden) 135, and if (as proposed in our former Reports) the toll levied was at the rate of 2 Rupees per 100 maunds, it will be seen that the annual income derivable from the work would be upwards of 5,80,000 Rupees.

48. By careful and necessarily very laborious examination of the system of levels, transverse, and longitudinal, furnished by Lieutenant Cunningham, and on consideration of the rates of labour ascertained, it appears that in the *line of least cutting*, and that otherwise best adapted for the navigation, the quantity of earth to be excavated would amount to 41,100,000* cubic yards, which, at the rate of 20 cubic yards to a Rupee, will cost in digging 20,55,000 Rupees.

49. The rate of digging here taken, may however be considered a high one, as in the table of the rates given by Lieutenant Cunningham, he states the cost of excavating "Tanks near Jummookandee to the depth of 21 feet," or that ascertained by the "Rajmahl Canal Survey," to stand *per Rupee* as follows.....

458 cubic feet,
578 ditto ditto,
686 ditto ditto,

the average of which is 574 cubic feet, or $21\frac{1}{3}$ cubic yards for a Rupee, and it is to be observed that this is for excavating Tank work (in which the earth raised has to be carried a great distance) to the depth of 21 feet, whilst the *average depth* of digging in the Canal will only amount to $19\frac{3}{4}$ feet.

50. The total cost of the four river crossing dams, viz. that of the Adji 6 feet in height, that of the More

* See page 128 of Calculations.

and Queea $6\frac{1}{2}$ feet in height, that of the Dwarka 6 feet in height, and that of the Bansli, which regarded as a dam, would be 12 feet in height, (but which in reality would consist of a cast iron channel for containing the water of the Canal, supported on low piers of masonry, between which, at the conclusion of the inundation, and during the dry season, the drainage water from the westward would run off,) would be 3,81,198 Rupees.* In this calculation, the cast iron work of the piers, and balanced sluice gates, has been estimated at the rates at which it could be executed in this country by pig-iron brought from England.

51. The expense of each lock may approximately be estimated at 70,000 Rupees, and as there would be 6 of them, this would make their total cost 4,20,000 Rupees.

52. The expense of small drainage bridges, or aqueducts, and of road bridges, and of stop-gates, may be taken at 3,50,000 Rupees.

53. With reference to these items, the total approximate estimate will stand as follows :

	Rupees.
Cost of excavating 41,100,000 cubic yards of earth at 20 cubic yards per Rupee,	20,55,000
Four river crossing dams,	3,81,198
Six Locks,	4,20,000
Small drainage, or aqueduct, bridges, road bridges and stop-gates,	3,50,000
Total Rupees,.....	32,06,198
Add for contingencies at the rate of 20† per cent.,.....	9,41,239
Total Rupees,.....	38,47,437

* See page 90 of Calculations and page 128.

† See page 192 of Calculations.

54. If the latter sum be called 40 lacks, it will be perceived that the annual income, previously estimated at 5,80,000 Rupees, would on that amount be at the rate of $14\frac{1}{2}$ per cent.

55. The slope or fall of 1.053 inches in a mile, proposed to be given to the bottom of the Canal,* will not merely insure its constantly receiving from the Ganges the quantity of water requisite for lockage, and that required to make up for the losses by leakage, soakage, and evaporation, but will also enable it to afford a large supply for the purpose of agricultural irrigation. A further supply available for this object, and as the means of meeting these losses, it has previously been noticed, will be afforded by the drainage water brought down from the districts *to the westward* by the rivers and nullahs intersected by the line of navigation, and to which it will serve as a catch-water drain.

56. As by means of such irrigation, the entire extent of land (much of it now lying waste) situated on each side of the Canal, would be rendered fit for the cultivation of sugar, tobacco, oil seeds, flax, and other varieties of crops, and produce, which by the Canal could be carried to Calcutta, or to the best markets, at the lowest possible rates, it is obvious that the value of the ground thus affected would be considerably enhanced, this for some distance inland, to the extent of 2 or $2\frac{1}{2}$ Rupees per acre.

* The effect of this *slope* in diminishing the height of the four river crossing dams (of itself an important object) has already been pointed out. And it may be remarked that this *modification* of the (general) plan contemplated by us, at the time Lieutenant Cunningham's Reports were prepared, with that which has here been described respecting diminishing the number of locks, constitute the *only* changes affecting the principle of the plan, we have ultimately concluded, would be expedient.

57. By obtaining, previous to the commencement of the work, possession of some of the extensive adjacent tracts now remaining uncultivated, the parties who engaged in the undertaking would from this source alone be able to derive large profits.

58. As the line would pass near many large villages, it is certain that these would speedily be extended along its sides, and early have *their* number added to, this in a manner calculated to give additional value to the property on either side, *by others* withdrawn from the *banks of the Bhaugirruttee*, sites in which, during the season of inundation, they are constantly in danger of destruction.

59. The *localities* in which, within accessible distances, stone or materials adapted for building, are to be met with, have been pointed out in our previous Reports; as *have also those* of beds of iron ore, and of coal, (the latter since experimentally brought into use,) which the Canal would either intersect or closely approach.

60. So situated, we conceive the total cost of the work would not exceed an amount which, as regarded profits, would be sufficiently remunerative ; as further, that by accomplishing the objects contemplated, its construction could not fail of realizing benefits calculated progressively to increase, and early to give rise to other improvements, similarly tending to add to the agricultural and commercial resources of the country.

D. MACLEOD, Col., } *Member of the Rajmahl*
Chief Engineer, } *Canal Committee.*

W. N. FORBES, } *Member of the Rajmahl*
Major, Engineers, } *Canal Committee.*

RAJMAHL CANAL COMMITTEE, }
February 15th, 1841. }



A

STATEMENT AND REMARKS

RELATING TO THE

EXPENSES OF IRRIGATION FROM WELLS IN THE DECCAN, KHANDESH, &c.

BY

CAPTAIN MEADOWS TAYLOR,

DEPUTY COMMISSIONER, RAICHORE COAH.

—C2569—

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—
1856.

No. 135 of 1856.

CIVIL DEPARTMENT.

From Captain MEADOWS TAYLOR,
Deputy Commissioner W. D.,
To, the SECRETARY TO GOVERNMENT,
Revenue Department, Bombay.

SIR,—I have been for some time past collecting data for an estimate of the expenses of Irrigation from Wells per acre in the Deccan, and the Collectors of the

Sholapore.
Ahmednuggur.
Poona.
Khandeish.
Belgaum.
Dharwar.
Sattara.

Zillahs mentioned in the margin, belonging to the Bombay Presidency, have been so good as to afford the information I required: As the result, in a collective form, may possibly be interesting to the

Right Honorable the Governor in Council, I have the honour to forward herewith copy of the tabular statement and report on the subject made by me to Mr. F. N. Maltby, Commissioner of the Hyderabad Assigned Districts.

I have the honour to be, &c.

(Signed) MEADOWS TAYLOR,
Deputy Commissioner W. D.

*Deputy Commissioner's Office,-
Nuldroog, 3rd August 1856.*

**STATEMENT showing the Average Yearly Expenses attendant
Zillahs of the Deccan, and the Average Amount of Land
Talooka of each Zillah, by the several Collectors and Deputy**

Number.	Names of Zillahs.	No. of Talookas in each Zillah.	The Expense of making a Mote, &c. per Year, and keeping it in Repair.				
			Making Mote with Leather, &c.	Iron-work per Year.	Wood-work and Ropes per Year.	Current Repairs during Year.	Total.
1	2	3	4	5	6	7	8
			Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
1	Zillah Nuldroog.....	10	4 5 7	1 15 7	5 14 5	1 6 4	13 9 11
2	„ North Berar.....	16	6 7 6	3 9 5	3 10 11	6 7 11	20 3 9
3	„ Sholapore.....	9	6 0 0	0 9 2	8 0 0	1 0 0	15 9 2
4	„ Ahmednuggur.....	14	4 12 9	0 10 8	4 8 0	1 0 0	10 15 5
5	„ Poona.....	7	4 15 5	2 1 7	5 13 2	1 15 1	14 13 3
6	„ Khandeish.....	16	4 13 0	1 13 6	10 6 7	1 13 4	18 14 5
7	„ Belgaum.....	11	4 1 7	3 6 1	7 6 0	2 6 0	17 3 8
8	„ Dharwar.....	8	7 3 0	2 12 0	4 5 6	1 7 6	15 12 0
9	„ Sattara.....	11	4 9 6	2 0 1	6 9 1	2 5 10	15 8 6
10	„ E. Raichore Dooab.	5	6 9 7	Not given	Not given	5 8 10	12 2 5
11	„ W. Raichore Dooab.	7	*14 0 0	1 9 7	1 1 0	5 0 0	21 10 7
	Total.....	114	67 13 11	20 7 8	57 10 8	30 6 10	176 7 1
	Average..	..	6 2 8	1 13 9	5 3 11	2 12 3	16 0 8

* Doubtful, but as given.

REMARKS.

† NOTE TO COLUMN 10.—Particulars of average of charges in Column*10 may

Feed of 4 bullocks for 1 year.....
Proportion of loss of cattle by death.....
Mussala and physic, &c., incidental expenses.....
Interest on Capital Rs. 185-3-4 at 12 per cent. per

In Nos. 1, 2, 3, 4, 10, 11, the expense of feed of cattle only is entered; in the others incomplete, but it does not seem necessary to refer back for other particulars to those

§ NOTE to Column 14.—The sum of 185-3-4 includes the total cost of the bullocks; Therefore 42-11-7 average, ÷ 6 years = 7-1-11 — 42-11-7 = 35-9-8 remainder, including above proportion of cost of bullocks. This divided by 4-5 beegas or acres,

*Deputy Commissioner's Office,
Nuldroog, 9th September 1856.*

on working a Well, with four Bullocks, for Irrigation, in Eleven irrigated from each Well, compiled from Returns furnished for each Commissioners of the Zillahs.

Expense of Bullocks per Year.		Expense of Men's Labour per Year.			Total of Expenditure per Year.	Average Quantity of Land watered by one Well in each Zillah, Beegas or Acres.	Average rate of Expense on each Acre or Beega in each Zillah.
Cost of Bullocks, Average of kinds used.	Feed of Cattle and other Charges on Capital.	Man to drive Bullocks of Mote, &c.	Man to turn off Water per Year.	Total Labour.			
9	10	11	12	13	14	15	16
Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	B. Pds.	Rs. a. p.
40 0 0	42 0 1	25 9 7	26 12 10	52 6 5	148 0 5	4 ..	37 0 1
40 0 0	47 0 8	30 0 3	28 3 0	58 6 0	165 10 5	2 12	63 11 0
40 0 0	38 0 0	36 0 0	30 0 0	66 0 0	159 9 2	5 ..	31 14 7
40 0 0	33 12 0	36 0 0	36 0 0	72 0 0	154 11 5	5 ..	31 5 6
40 0 0	79 14 3	40 4 7	32 1 2	72 5 9	207 1 3	4 4	49 4 10
70 0 0	107 7 6	31 10 0	22 10 0	54 4 0	250 9 11	4 18 1	50 14 2
40 0 0	101 8 0	33 0 0	28 12 9	61 12 9	220 8 5	4 4	52 8 1
40 0 0	93 14 0	35 0 0	30 8 0	65 8 0	215 2 0	6 10	39 1 9
40 0 0	92 9 1	32 13 10	28 7 0	61 4 10	209 6 5	2 11 1	45 12 4
40 0 0	46 0 0	25 6 5	25 6 4	50 12 9	148 15 2	3 ..	49 10 4
40 0 0	40 0 0	39 0 0	15 0 0	54 0 0	155 10 7	6 ..	25 15 1
470 0 0	722 1 7	364 15 5	303 13 1	668 12 6	2037 5 2	48 ..	477 1 9
† 42 11 7	† 65 10 4	33 2 10	27 9 11	60 12 9	† 185 3 4	4 5	43 5 11

† Share per year Rs. 7-1-11.

be thus classed :—

	Rs.	a.	p.
.....	30	0	0
.....	10	0	0
.....	3	6	9
year	22	3	7

Total..Rs. 65 10 4

incidental expenses are included. In reference to the first, the detail of the Return is Zillahs.

but as 4 bullocks last 6 years, a proportion of cost is to be taken :—

which deducted from 185-3-4, leaves a balance of 149-9-8 as the total cost average, gives Rs. 35-3-8 as average cost of Irrigation for each acre per year.

(Signed) MEADOWS TAYLOR,
Deputy Commissioner W. D.

No. 447 OF 1856.

From Captain MEADOWS TAYLOR,
Deputy Commissioner W. D.,

To F. N. MALTBY, Esq.,
Commissioner, Bolarum.

SIR,—Since addressing you on the subject of Irrigation in general, in letter No. 438, of the 5th instant, I have received the report of the Collector of Khandeish in relation to the cost of Irrigation in that province, which was required to make up the series I proposed to submit for your consideration.

2. I have now the honour to enclose a tabular statement of eleven Zillahs of the Deccan, including 115 Talookas, and comprising the whole of the Assigned Districts, except Southern Berar, my application to the Deputy Commissioner there having received no reply. I should not suppose, however, had it been forwarded, that the expenses detailed would have made any material difference in the general average result.

3. The data taken by Punchayets of respectable farmers in every Talooka of so wide an extent of country, might reasonably be expected to differ in result; but, on the whole, the particulars are more uniform than I expected, though a few manifest differences need to be noticed. In Western Raichore, for instance, the price of "mote," column 1, is stated as Rs. 14, but as it could not possibly amount to so much, it is probable that some other gear peculiar to the district is included in the sum, which is not explained by the Deputy Commissioner. In column 6, for wood-work,

Sholapore and Khandeish give the highest rates. Wood of every kind is very scarce and dear in the Sholapore Collectorate, and is probably the same in Khandeish. But on the whole expenses of mote-gear for the year there is no very material difference, Northern Berar and Western Raichore being the highest.

4. The cost of bullocks in column 7 is given on an average of prices of cattle employed, and is taken at the same rate throughout, except in Khandeish, where the cattle are larger, and the water in many Talookas has, I understand, to be raised from a considerable depth. Four bullocks employed in mote work, usually last on an average six years; therefore, though the whole price is included in the gross total of the return, I have added a foot-note in explanation of the actual result on the proportion of the price of cattle being added instead of the whole.

5. Column 10 shows the expenses of feed of cattle and other incidental expenses, the average of which is Rs. 65-10-4, and is accounted for as to particulars under the head of Remarks.

But the items of these expenses are very irregular in amount, which may be accounted for by the bare keep of the cattle only being included in Zillahs Nos. 1, 2, 3, 4, 10, and 11, and in the others by other incidental charges having been included, which, if added (as indeed is necessary) to the first mentioned six Zillahs, would increase the average charges very considerably.

6. In estimating interest on capital, I have taken 12 per cent. per year, but I am of opinion that this rate is much too low. The ordinary rates of money transactions with Sowcars is 24 per cent., but as money seldom passes between the cultivator and the dealer,

and grain is given, and as the usual rate of grain transactions is Rs. 25 per cent. in the gross (not contingent on charge of price), the rate of interest would be probably higher than 12 per cent. on money only. Twelve per cent. per year, however, represents a standard value of capital, and may be accepted in lieu of more detailed data.

7. Columns 11 and 12 show the rates of hire of men to work the mote. These men are indispensable; one has to drive the bullocks, and the other to turn off the water into the beds as required. In column 11 Poona gives the highest rate, and it is probable that labour there is more expensive than elsewhere; but wages are evidently not over-rated in any case, as the two columns give averages of Rs. 32-2-10 and 27-9-11 respectively per year, or Rs. 2-14-10 and 2-4-9 per month per man.

8. In the column of totals of expenditure, No. 14, it will be seen that Khandeish gives the highest rate, which evidently arises from the greater value of the cattle and wood-work employed, for in regard to other items there is no particular difference between it and other Zillahs.

9. Column 15 shows the average quantity of land watered by one well in each Zillah, and, on the whole, there is no remarkable difference. The two least are Northern Berar and Sattara; both I may say equal 2·12 acres. Western Raichore is set down as 6 beegas or acres as ~~average~~ to a well; but I have great doubt as to the correctness of this,* and believe, from my own

* Why should Western Raichore be 6 beegas, and Eastern Raichore only 3½? The latter is, I suspect, right, and agrees with results in Sholapore.

experience and constant observation, that from three to four acres is the most that is practicable, without there are relays of bullocks to the well, which is not provided for in the estimate. A good mote-gear and cattle will barely irrigate more than one acre a day, and the water requires to be turned on every fourth day—indeed, every third day in the hot weather, to each portion. On these grounds I consider six acres too much, though it is entered according to the return furnished; but if the local beega is less than the acre, it may not be so much as it appears.

10. The average from the total under this head is acres 4·5, or $4\frac{1}{2}$ of land, irrigable from one well, with four bullocks; and the average expenditure of raising the water is, by the next column, gross Rs. 43-5-11 per acre.

11. But as explained in the foot-note to the return, and the proportion only of the price of cattle being included in the total, it is reduced to Rs. 35-3-0 per acre per year; I say acre, because the beega is indefinite everywhere, and is in no case a standard of measurement. Sholapoor, Poona, Belgaum, Dharwar, and Sattara have been measured, and the English acre is the standard in those Zillahs. Our districts and Khandeish have a nominal beega, but, as stated above, unless the beega in Raichore is less than the acre, which it may be, the beega in general will be found to correspond pretty nearly with the acre, and sufficiently so perhaps for an estimate of this kind. Were it *less*, it is unnecessary to state that the expense of irrigation would be increased in proportion.

12. It will be observed in the estimate, that it has been confined to the expense of *raising water only*; considerations of the repair to the well, clearing out of

mud every year, occasional repair of the sides, and water channel, &c. &c., and the original cost of the well itself, or interest on that cost, have been purposely avoided; but that these expenses, which occur inevitably, on an average of wells, form an additional item of cost, will no doubt suggest itself to you.

13. While the gross average cost has been assumed, however, as Rs. 35-3-0 per acre per year, it is necessary to allow for some period in which the well may not be used, and by common acceptance in the Deccan we may take three months clear (though perhaps this is too much in ordinary seasons, and two would be safer) in which, on account of the monsoon, the well is not used. If three months are assumed, one-fourth, or Rs. 8-12-9 has to be deducted from Rs. 35-3-0, leaving a balance of Rs. 26-6-3; if two months, one-sixth or Rs. 5-13-10, leaving a balance of Rs. 29-5-2, and the average of these balances is Rs. 7-13-8½, beyond which I do not think the rate can be reduced; while it is evident that many considerations which would materially increase it are not included in the estimate.

14. It appears then from the foregoing, that the bare expense of raising water from a well in the Deccan generally, is not less than Rs. 27¾ per acre per year, and it is evident also that had all expenses and charges been included in all the Zillahs, the result would have been a considerably higher figure; nor does this result surprise me, as I have been making inquiries on the subject for many years past, and have observed nearly the same rates everywhere; indeed, I was prepared to have seen it more.* I have included no

* Colonel Cotton says that about Rs. 30 per acre is the cost of well-water for sugarcane in the Northern Sircars.

expenses of manure, cultivation, or Government demand, as these are entirely separate considerations from the subject of the cost of Irrigation.

15. But in order to make the estimate as nearly as possible correct for this District, and to include in one view the various items of expense, &c. detailed in the statement, I beg your consideration of the following particulars :—

ZILLAH NULDROOG.

Expense of making a Mote per year.

	Rs.	a.	p.
Leather bag	4	5	7
Proportion of iron-work, per year	1	15	7
✓ Wood-work, ropes, and gear, proportion of, per year.	5	14	5
Current repairs	1	6	4
	<hr/>		
	13	9	11

Expense of Bullocks.

Cost of 4 bullocks, 2 at Rs. 12 = 24, and 2 at Rs. 8 = 16 . .	40	0	0
Feed of cattle, &c. including medicine, &c.	42	0	1
Average proportion of loss of cattle by death in 6 years . .	10	0	0
	<hr/>		
	92	0	1

Expense of Labour per year.

Man to drive mote bullocks . .	25	9	7
Man to turn off water	26	12	10
	<hr/>		
	52	6	5

Brought over	Rs. 158 0 5
Interest on capital as above, Rs. 158-0-5, at 12 per cent per annum	18 15 4
	<hr/> Rs. 176 15 9
Deduct for proportion of value of cattle calculated to last 6 years, one year's share only being retained in the estimate	33 5 4
	<hr/> Gross expenditure per year . . Rs. 143 10 5
Gross proportion of cost on 4 acres watered	Rs. 35 14 8 $\frac{1}{4}$
	<hr/> Gross average as above contained for 12 months, per acre Rs. 35 14 8 $\frac{1}{4}$
Deduct, for well being out of use for 2 $\frac{1}{2}$ months in the year, proportion of gross cost	7 7 9 $\frac{1}{4}$
	<hr/> Total net cost of Irrigation per acre per year Rs. 28 6 11

16. My object in collecting this information is to show the comparatively enormous disproportion which results between the cost of Irrigation from Tanks or Anicuts in other localities, and that from Wells in the Deccan. I am not fully aware of the rates of irrigated land in the North-West Provinces, or the rate at which the water is supplied to the people per acre from the Government Canals; but my impression is, that both water charge and ground rent do not amount to more than five rupees per acre on garden land in *any* locality, if indeed so much.

17. The Madras Report for Fuslee 1263, however, gives detailed information of average of assessment at page 10, para. 24 ; and I observe the highest average for "Wet Cultivation" per acre is in Bellary, which is Rs. 9-14-1, and of Garden Baghayet in Southern Arcot, which is Rs. 13-4-9. The former, I presume, includes the water rent, that is, the Ryot is furnished with water and land for the charge of Rs. 9-14-1 per acre. Whether the water is provided in the second case or not I do not know, but most likely it is, or such a rate for land alone could not be sustained. What the proportion of land rent and of water value may be in the first case is not shown ; - but assuming the *land rent* to be *at the outside* two rupees per acre, the water rent would be represented by Rs. 7-14-1 per year, and this, which is possibly an exaggeration, does not represent by Rs. 19-15-7 per acre the cost of Well Irrigation on the general average, or by Rs. 20-8-10 on the average, for Nuldroog, of Well Irrigation.

18. If, as I believe is the case in Hindoostan, the canal water rate per acre is fixed at two rupees (Colonel Cotton says one rupee) as a maximum, the difference is still more startling.

19. I need not dwell further on the subject of expense ; your own extensive experience in the Madras Presidency will no doubt suggest to you data for comparison of the rates I have given, of which I have no knowledge ; but I may be allowed to point out what saving would occur to the farmer here, provided he could be supplied with water from a tank or channel instead of a well. I will presume, therefore, that the water rent per acre was fixed at Rs. 5, though it would not perhaps

offered, and what all Ryots with whom I have discussed the subject declare to be perfectly fair.* Were it so, the immediate saving would be Rs. 23-6-11 per year to the Ryot on each acre of irrigation in Nuldroog, but the benefit does not end here. Four of his most valuable bullocks are released from work which cannot be neglected for a day, and become available for other employment; and he would have one more farm servant at liberty. He would thus be able to extend his dry cultivation or to improve what he has; and it is too often observable that owing to a man's cattle being employed in irrigation of his garden field, his other fields are not ploughed so well, or kept as clean as they need to be. I need not, perhaps, pursue the details further, as they are very obvious.

20. In the Deccan, generally, as in this Zillah, it is the value of produce alone which enables a farmer to pay the enormous expense of Well Irrigation. He raises sugar-cane and vegetables, or ginger, pan, plantains, or turmeric, and wheat or barley, with chillies, hemp, and the like, as a second crop; and, by working his well perpetually, contrives, by a rotation of crops, to get two or three per year, except sugar-cane. He does not grow rice, for it would not pay at all. If we suppose that he was provided with cheap water, it is clear, while he would be able to obtain the same crops from his land as he did before, that he would get them for less than one-fifth of the outlay as far as the principal expense—water, is concerned, and would, in addition to

* In one instance, by the Ryots of Narunj and Jowla, Talooka Ashti, I was offered Rs. 15 per acre, after a long deliberation among themselves as to expenses; the estimate was about Rs. 30 per acre, and they offered half.

his cattle and men being at liberty, be proportionably benefited.

21. I have always heard the farmers here and in the Deccan generally, express themselves as hopeless in regard to the reduction of their irrigation expenses, and I do not wonder at it. Government, in the Bombay Revenue Survey, reduced the assessment on garden land very materially, I believe, and to its own heavy loss; but to what practical relief to the farmers! Suppose Government remitted a rupee an acre to a man here who was paying Rs. 28-6-11 an acre for his water alone, it would in point of fact be nothing material to him. But if Government, instead of remitting the rupee, could give him water for 5 rupees an acre instead of his paying Rs. 28-6-11, it need not reduce its rent, and it is needless to say how great a boon it would confer.

22. Again, there has often been and still is, a cry for more wells, and some new wells are occasionally dug; but people who dig them, without they happen to touch a spring very soon, and incur little expense, complain bitterly that they do not pay, and no wonder. What can they possibly do with this incubus over them in the shape of the expense of raising the water? The more wells that are dug and employed too, the more cattle and more labourers are withdrawn from other field work; for every well must have its four, oftener six bullocks apportioned to it, which are rarely employed otherwise, and in every case two men.

23. In further relation to this subject, if the data now furnished is considered fair, I will endeavour to ascertain the average quantity of water raised by a mote per day and expended per acre; and calculating

its value per cubic foot or yard, report the result. But I trust that the foregoing forms strong ground for the speedy commencement of a system of Irrigation by Tanks for this province, and shows that while it is quite hopeless to expect any material extension of garden cultivation, so long as water costs what it does from wells, and that no reduction of assessment would serve any practical end, or effect any practical relief, it will be a sound and benevolent policy on the part of Government, attended, I think, with ample profit to all concerned, to store up and sell to the people, at reasonable rates, those large bodies of water which this district could supply to hundreds of noble tanks, but which now run utterly to waste. I have before stated that the Railway will be on our frontiers in two years, and our garden produce is what it will most require for supplies of traffic. Why should not we, then, by works of Irrigation, do something in anticipation of the benefit we hope to derive from its construction ?

I have, &c.

(Signed) MEADOWS TAYLOR,
Deputy Commissioner W. D.

*Deputy Commissioner's Office,
Nuldroog, 9th September 1856.*

(True copy)

(Signed) MEADOWS TAYLOR,
Deputy Commissioner W. D.

No. 4186 of 1856.

TERRITORIAL DEPARTMENT,
REVENUE.

To Captain MEADOWS TAYLOR,
Deputy Commissioner Western Districts,
Nuldroog.

SIR,—I am directed to communicate to you the thanks of Government for the valuable and interesting Report forwarded with your letter No. 135, dated the 3rd August last, relative to the expenses attendant on working wells for irrigational purposes in the Deccan, &c.

I have the honour to be, &c.

(Signed) H. YOUNG,
Officiating Chief Secretary to Government.

Bombay Castle, 25th October 1856.

No. 184 of 1856.

From Captain MEADOWS TAYLOR,
Deputy Commissioner W. D.,

To H. YOUNG, Esq.,
Secretary to Government,
Territorial Department, Bombay.

SIR,—In acknowledging receipt of your letter as per margin, I beg you will do me the favour to convey my sincere acknowledgments to the Right Honorable the Governor in Council for its tenor. As the subject was incomplete without ascertaining averages of quantity of water raised from wells and its cost to the people, I have taken averages of discharge from wells for some time past, and beg to transmit the result, in copy of a letter No. 610, under date 29th instant, to the Commissioner of the Hyderabad Assigned Districts, for the information of the Right Honorable the Governor.

2. I avail myself of this opportunity to forward also copy of a previous letter to the Commissioner, No. 438, of 5th September, which completes the series of correspondence on this subject.

I have the honour to be, &c.

(Signed) MEADOWS TAYLOR,
Deputy Commissioner W. D.

*Deputy Commissioner's Office,
Nuldroog, 4th December 1856.*

No. 610 of 1856.

From Captain MEADOWS TAYLOR,
Deputy Commissioner W. D.,

To F. N. MALTBY, Esq.,
Commissioner, Hyderabad.

SIR,—In reference to para. 3 of letter from the Second Assistant Resident, of 23rd September, as per No. 1852, regarding Irrigation, margin, I have the honour to submit a few results in regard to the quantity of water raised per year per well, on averages obtained from different wells with different lengths of rope.

2. 1st.—A mote at Nuldroog, of which the rope is 72 feet, filled a cistern 1 foot 8 inches deep, 23 feet 9 inches long, 21 feet broad, or 831 cubic feet, in four hours by 150 motes; the cubic contents of one mote is therefore 5.54 cubic feet.

2nd.—By the data given in the letter under reply, the cistern at Hyderabad contained 339.29 cubic feet, and the contents of the mote was 3.777 cubic feet.

3. The average contents of these motes is 4.658 cubic feet.

3rd.—The mote No. 1, carefully filled by ghurras of water poured into it before it was raised, contained as nearly as possible 7 cubic feet of water, but the actual discharge being 5.54 only, it follows that 1.46 cubic foot of water were lost in the ascent and discharge into the channel; and it will always be observed, when the mote is first raised by the jerk of the bullocks, that

a good deal of water escapes, that more escapes as it ascends, and a further quantity when the foot of the bag reaches the roller at top, throwing the bag backwards. I consider, therefore, as all motives are not in perfect repair, that an average of 4.658 cubic feet to each bag is a fair one of the actual discharge of water, and have adopted it in the calculations I have followed.

4. An average of length of ropes, and including the Nuldroog rope of 72 feet, and assuming the Residency rope to be 42 feet, gives an average per well of 31.40 feet for rope.

5. An average of discharges of motives per hour, including the Nuldroog and Residency data, gives 53.60, or, on the above average of cubic feet 4.658 per mote, a discharge for irrigation of 249 cubic feet per hour.

6. On the above data the following averages of data are taken:—

Average of mote 4.658 cubic feet ; discharge average 53.60 times per hour ; when rope is (average) 31.4 long, discharge per hour 249.66 cubic feet.

7. *1st Result.*—Mote working 8 hours per day, for 9 months, at the above rate:—

249.66 cubic feet \times 8 hours \times 30 days \times 9 months
 $= \frac{539265.60}{27}$ cubic feet $= \frac{19972.80}{4.12 \text{ acres per well}^*} = 4,847$ cubic
yards of water for each acre per year.

2nd Result.—249.66 cubic feet \times 9 hours per day
 \times 30 days \times 9½ months $= \frac{640377.90}{27}$ cubic feet $=$
 $\frac{23717.70}{4.12}$ cubic yards $= 5,756$ cubic yards per acre per
year.

* Vide para. 10 of letter No. 447, of 9th September 1856.

✓ *3rd Result.*— 249.66 cubic feet $\times 10$ hours a day $\times 30$ days $\times 9\frac{1}{2}$ months $= \frac{711531.00}{27}$ cubic feet $= \frac{26353}{4.12}$ cubic yards $= 6,396$ cubic yards per acre per year, of which a new average is taken:—

Hours per day.	Months.	Water raised C. yards.
8	9	4,847
9	$9\frac{1}{2}$	5,756
10	$9\frac{1}{2}$	6,396
<hr/>		<hr/>
Average 9	$9\frac{1}{3}$	5,666.6 C. yards

of water per acre per year.

8. But the Nuldroog and Residency motes being of extraordinary height, not in general use, and not to be found in this District, an average of a number of ordinary wells was taken, which resulted in $14\frac{1}{2}$ feet of rope per well. An average of actual mote discharges per hour from these wells was also taken, and is 61.

Therefore, as before, 4.658 cubic feet per mote $\times 61$ motes $= 284$ cubic feet per hour $\times 9$ hours $\times 30$ days $\times 9\frac{1}{3}$ months $= \frac{715683}{27}$ cubic feet $= \frac{26506 \text{ C. yards}}{4.12 \text{ acres}}$ $= 6,431$ cubic yards per acre per year.

9. Now taking, as per para. 13 of letter No. 447, of 9th September 1856, the expense of irrigation per acre per year to be Rs. 27-12, or 27.75, we have on the first average $\frac{5666.6}{27.75} = 204$ cubic yards per rupee; and on the second average, with the shorter average of ropes and greater number of motes per hour, we have $\frac{6431.00}{27.75} = 231$ cubic yards per rupee.

10. It will be evident that the above data are subject to many fluctuations, such as length of rope, capacity of bag, time of working, whether hours per day or days per year, and the like; and it is objected

to by many persons that I include 10 hours a day in my calculation, when hardly more than 8 hours can be got out of ordinary bullocks. I wish, however, to give the greatest quantity of water the data will allow me, in order to contrast it with what would be the result of irrigation from tanks or channels; and by the two general results above given, viz. $6,431 + 5,666 = \frac{12097}{2} = 6,048$ cubic yards, which agrees with Captain Baird Smith's data from discharges of irrigation works in proportion to ground irrigated, 6,000 cubic yards of water may therefore be taken as a safe average per acre per year on all lands which require, as rice or sugar-cane, continual irrigation. But it will be evident to you that for ordinary vegetable and other products, such as grain, which require only occasional watering, a much less quantity is needed, and that a cubic yard of water per square yard per year, or say 4,840 cubic yards to an acre would be enough. In estimating the quantity of water in tanks as to be applied to irrigation, I have hitherto taken 5,000 cubic yards per acre; and an average of $4,840 + 6,048$ is 5,444. It will be safer in future to adopt 6,000, as leaving perhaps a margin for contingencies in all estimates.

11. My proposal has been to give the people water for Rs. 3 per acre per year at first; and I have hoped that even Rs. 5 would be realised. At the rate of Rs. 3 per 6,000 cubic yards, the Ryot would receive 1,888·8 cubic yards per rupee, or 0·10 pie per cubic yard; at Rs. 5 per 6,000 cubic yards, 1,133·3 cubic yards, or 0·17 pie per cubic yard; while by the result in para. 9, of 204 cubic yards per rupee, it costs the Ryot 0·94 pie per cubic yard, and on the second average, 231 cubic yards, 0·83 pie per cubic yard. In other

words, the saving to the farmer, in paying 0·10 pic per cubic yard instead of 0·94 pic, would be 89 per cent., and in paying 0·17 pic instead of 0·83 pic, 80 per cent.

12. During my tour in the District I purpose to obtain further data as to length of ropes of motes and their actual discharge per hour, and should I find any material difference with the above, I shall do myself the honour to report it.

I have the honour to be, &c.

(Signed) MEADOWS TAYLOR,
Deputy Commissioner W. D.

*Deputy Commissioner's Office,
Nuldroog, 29th November 1856.*

(True copy)

(Signed) MEADOWS TAYLOR,
Deputy Commissioner W. D.

No. 438 of 1856.

From Captain MEADOWS TAYLOR,
Deputy Commissioner W. D.,

To F. N. MALTBY, Esq.,
Commissioner, Bolarum.

SIR,—I have the honour to acknowledge the receipt of your letter No. 1687, as per margin, and in reference to its purport, beg to state, in continuation of my letter No. 416, of the 25th ultimo, some further details and considerations on the subject to which it refers.

No. $\frac{1687}{337}$ of 29th August 1856, in regard to the non-existence of Tanks in the Western Districts.

2. That tanks do not now exist in this District is not because the experiments made in ancient times were *unsuccessful*, but that it is evident none were ever fully completed. Not one of the remains of bunds that I have already alluded to shows evidences of having been finished, and to have been broken by flood; nor is there any appearance of any tank having been used, and having silted up with mud so as to become useless. For instance, not one of these commencements of bunds have sluices for irrigation, nor in any case is the stone facing of the earth-work completed, and the irregular condition in which the works have been left in every locality, proves plainly that they are one and all commencements only of some project for storing up water, which was perhaps designed for the whole District, and partially executed, and abandoned either during changes of authority or the convulsions of a disturbed period.

3. If there were evidence in any instance of a tank having been completed, and having silted up so as to become useless, it might be an argument that the drainage from the water-sheds in this District carried too much mud with it to render the tank into which it would fall available for holding water for many years in succession.

On the other hand, if all the present ancient bunds showed evidence of having been completed and of having burst suddenly, it might be again argued that the soil of the bunds would not hold water and had yielded to pressure, and so discouraged the projectors.

Or, if there were any tank bund in a complete state at present, into which water flowed, was temporarily retained, and afterwards sunk or percolated through

the bed of the basin, it would amount to proof that the substratum of rock or soil was unfitted for the purpose of retaining water.

But none of the above are apparent in any case that I have seen as yet, and we have evidence, as will be presently stated, to the contrary of these remarks.

4. For instance, in regard to abandoned undertakings of magnitude, which are not failures, the greatest is the noble design of a tank at Bhatoree in the Ashtee-Talooka, which was begun by Sulabut Khan, a Prime Minister of the former Ahmednuggur kingdom, and which still bears his name. This consists of an irregular earthen bund, partly faced with solid masonry in lime, but evidently abandoned when about half completed. Of this work the tradition is, that it was stopped because the people of a village above the bund petitioned the King that it might not proceed, as the village would be submerged; but it is also stated, with probably more truth, that the political troubles of the period prevented its completion. The design is an admirable one, both in execution as far as it has gone, and also as to situation; and the area of water secured would have been very large, indeed probably equal to the Hussain Sagur at Hyderabad. This work could not be undertaken now, as the bund happens to be on the very frontier of the District, the area above it being in the Ahmednuggur Collectorate, and would involve the submergence of one, if not, indeed, two villages, with the whole of their lands, which would most probably be objected to by the Government of Bombay.

5. Greatly less in size certainly, but still the commencement of a fine work, is the partially executed bund at Kusba Nittoor, measurements and sections of

which were submitted with my letter of the 5th September 1855, No. 34. If these measurements are examined, I think they will prove to you that the work, as I have stated, is only a beginning. The bed of the basin is bare; there is no appearance whatever of silt in it; the sluice for irrigation is unfinished, so also is the calingula; the earth-work of the bund is only partially faced with stone, but what there is has never been disturbed by subsidence or fracture; the levels of the bund are irregular, showing that the earth-work was never carried up to the designed height: in short, ample proof exists to any one familiar with such works, that the tank could never have been completed or used. What has been done is attributed to the Rajas of Kullianee, by whom many fine tanks in the adjacent Kullianee districts, *now in use*, were constructed. This was a very ancient dynasty of Hindoo princes, whose era is not well known, but which was much anterior to the Mahomedan invasion, and is probably not less than a thousand years from the present period.

6. In other places, for instance below the Ghauts, from hence to Dharaseo, and indeed further on, numbers of small bunds are met with. Not one of these is faced with stone, but in some there are indications of the stone facing having been begun; not one of them has a sluice, and all present in contour those irregular heaps of earth which have resulted from a commencement of work and its sudden abandonment. Nearly all are in the same condition, but some are more advanced than others, and thus I have come to the conclusion that a system of tanks for irrigation had been designed and partially executed by some one, but had been abandoned before it could be completed and put to use.

7. Of all these bunds there are only two at present which hold water, but as they do not belong to us, I could not detail them in the return recently called for. They are the Kakera tank, which belongs to the Barsee Purguna of the Sholapore Collectorate, and a tank at Khanapoor near Dharaseo, both below the hills, and, as it occurs to me, are part of the system, if I may so term it, or general design, which it is evident was to have been completed in the gorges below the hills.

8. The Kakera tank has always held water, though it is evidently incomplete. The basin is an admirable one, formed by closing up two separate gorges of the hills, and the supply from the water-shed of the feeders is very ample to fill the basin. I say the original design is incomplete, because, in the northern gorge, which is the largest, the bund is about thirty feet in height, well faced with stone, and in all respects firm and good. The other gorge to the south, which should have had a bund on the same level as the northern one, has the beginning of one only, with a sluice in it which is incomplete. It is about eight feet high only, but the level of its base is owing to the ground on which it stands being rather higher than the base of the large bund. The tank, therefore, has never held more water than to the level of the smaller bund, which is partly broken; but the people of the neighbouring villages have been accustomed to retain two or three feet more water by throwing up a rough dam of loose stones and sods every year at the close of the monsoon, and using the water for the irrigation of sugar-cane fields below the tank.

9. The basin of this tank was so admirable a one in all respects, and the completion of the original design

so easy and inexpensive, that, as it did not appear to be known, I recommended it to the notice of Mr. Loughnan, the former Collector of Sholapore. The necessary levels were taken, and an estimate for its completion was sanctioned. The work was in progress when I last saw it, but I do not know whether it has been finished.

10. Now, though some mud had been deposited in the bed, it is not much, and if any very extensive silting up had resulted from the deposit from the drainage (probably during many centuries), it is impossible but that the basin must have been filled to the level of the smaller bund, and could contain no water at all; whereas it is evident that the silt has not yet reached its base, and the lake, in the condition it was before the new repair, was always a shallow, though considerable sheet of water, which never entirely dried up.

11. The Khanapoor tank, which belongs to an Inamdar (Kothenerre Purshad), has also never been completed to the original design. The irregularity in height and thickness of the present bund, shows that earth was thrown up in heaps, but never completed to the required level. It is not faced with stone. There is no sluice, or commencement of one, but a rocky ledge at the northern side serves to retain the water, and over it the surplus water escapes, as over a calingula. The water retained is, of course, shallow, probably eight or ten feet deep when the tank is full, but as the bund is incomplete, the central height of the earthwork not having been carried out to each side, the basin is little better than a jheel. It holds water, however, all the year round, and it is drawn off partially, after the monsoon, to some lands below the tank, for irrigation of rice and sugar-cane.

12. I need not, perhaps, enter into further details of other unfinished projects, but may state, in addition to the above, that a small tank near Mōujē Teerth of the Tooljapoor Purguna, with an unfinished bund, is made to some extent useful by the villagers every year, and holds water, which is used for irrigating a few sugarcane fields as long as it lasts. It evidently belongs to the same series as the others. It was inadvertently omitted in the return called for, but will be surveyed and an estimate made for its completion as soon as possible. At best, however, it is only a very small tank, and, therefore, of comparatively little importance.

13. Enough, perhaps, has been said to show that unfinished projects cannot be said to evince *failure* in any scheme of irrigation by tanks; and further, that where the bunds have been sufficiently finished, as at the Kakerā, Khanapoor, and Teerth tanks, a small portion of the water-shed drainage is retained throughout the year without loss by percolation.

14. It is necessary that you should have evidence on the latter point, because, until lately, I believe it was imagined that the trap or basaltic formation would not hold water, because the substratum of rock would be porous or full of fissures. But the same geological formation of the basins here, exists, I observe, at Vehar, which is to supply Bombay with water; and the bed of that large basin having been examined by scientific men, both Engineers and Geologists, has been pronounced sound, and the works are in progress. Here also we see the basins of the Kakerā, Khanapoor, and Teerth tanks holding shallow water

for the whole year, which could not be the case were the floor or beds unsound or porous.*

15. All the natural basins formed by gorges of hills in this District are of the same character. There is no appearance of shale or sand (both equally to be dreaded anywhere), but all along the bases of the hills the geological structure of the country is a close-grained wacke, which has no fissures and is not porous, and apparently much more impervious to water than the sandy granitic soils in which the tanks of the Hyderabad country, and generally of the South of India, are constructed.

16. The only point, to my perception, which has to be tested, is the quality of the earth of which the bunds have to be constructed, and its capacity to retain and resist water; and this can only be known by experience. The earth of all the old unfinished bunds has become certainly very firm. Wherever gorges of basins fit for damming up are found, deep black earth does not exist in them, and the soil is usually strong clayey moorum, which is tenacious and appears to bend very readily. There is no sand, which, as entering into the earth of a bund or existing in the bed of a basin, is always dreaded by tank-makers. There is everywhere abundance of blocks of stone on the hill sides for facings of tank bunds, and so far, therefore, as situation and

* A small tank at Latoor, recently repaired by the townspeople, also holds water well, and is situated in the same kind of geological formation as the others. And the lake at Nuldroog, which is nearly 60 feet deep, has no percolation, though the bed and sides are prismatic basalt.

Two tanks at Sholapore also, in the same kind of ground, hold water well all the year round.

material are concerned, there appears every inducement to execute works of irrigation in this province of great magnitude.

17. I believe it has also been advanced that irrigation is not suited to black or mixed soils; but this is surely a mistake, else why should irrigation from wells be applied to garden cultivation at an enormous proportional cost? and how can the best descriptions of garden produce—sugar-cane, turmeric, ground-nut, ginger, betel, and the like—be cultivated at all without irrigation? Black soil may not grow some descriptions of rice as well as red, but again there are some kinds of fine rice, such as are grown in this District for instance, which can only be produced in black soil; nor is the soil wholly black throughout, but much mixed—red, brown, and grey soils existing as well as black. My impression is, that had the people ample supplies of water, rice would not be so much grown as the more valuable products of sugar, ginger, turmeric, and the like, for which, in the Bombay market, there is an inexhaustible demand, and which are much more valuable.

18. Again, that water is valuable for wheat, grain, jowaree, and other rubbee crops, we have evidence in the Ashtce, Wansee, and other Talookas, where, by rude contrivances, the small hill-streams, as long as they last, are everywhere turned upon the adjacent fields after the monsoon, and one or two waterings are secured. The jealousy with which these small rude dams and channels are guarded by each village, is ample proof that the value of water is known, and its practical use

grown on dry land is too remarkable to escape notice. Indeed, wheat and barley are frequently irrigated from wells, and their produce must pay, or the expense of irrigation would not be incurred.

19. By whatever means, therefore, water could be supplied for irrigation in the District, my conviction is that a greater boon could not be devised for the people; and that they would, after a short experience, heartily avail themselves of it (setting aside considerations of constant application) appears in all respects equally probable. If garden cultivation pays them (as it must do, or it would be abandoned) even at the rate of more than Rs. 20 expenditure *per acre for water alone*,* it is hardly necessary to say that it would pay

Vide para. 15 of letter No. 447, of 9th September, for details showing average expense of 115 Talookas to be Co.'s Rs. 27-12 per acre; and para. 15 for details amounting to Rs. 28-6-4 per acre.

much better were the cost of water only Rs. 5 or 3. I should not fear over-production of valuable garden staples; the Railway, which will reach the confines of the District in two years, will take all we can possibly supply, for the Bombay market and shipment to Europe, of sugar, ginger, turmeric, oil seeds, and hemp.

20. In the above opinion, however, my own judgment is unsupported by that of men more experienced

* Vide former details of expenses in various Districts already submitted, which will be increased very shortly by details of the following Collectors:—

Poona	}	Received from Collectors.
Sattara		
Dharwar		
Belgaum		

than myself in irrigation works, and it is therefore given now, as before, with much diffidence ; and while I cannot refuse to report, for the consideration of Government, facts and circumstances in regard to the usefulness and practicability of the measure which carry conviction to my own mind, I should at the same time rejoice were any officer of mature experience to visit the District and judge for himself of the localities I could point out, whether for completion of unfinished works or projection of new undertakings.

21. The absence of works of irrigation here may be accounted for, I think, by other evident causes than alleged failure, and a few which presently suggest themselves to me may be briefly detailed.

22. We see all through the South of India, and wherever granitic soil prevails, that tanks are most numerous. This soil is in itself very poor—so poor, that it refuses to grow other than the cheapest and poorest grains, and those only in the monsoon ; but when water is applied to it, it becomes fertile and produces rice, which is the staple of the people's food. Without water existed for irrigation, therefore, the country is unfit to support a large population ; and did not the present tanks and other means of irrigation exist, it would no doubt be very scanty indeed. This must have been estimated, I imagine, at a very early period, and hence those noble works which we see in the Hyderabad country and in Southern India were projected and executed by the former Hindoo rulers.

23. We know also that these Hindoo families were locally rich and powerful at the time of the Mahomedan invasion : and that they had spent large amounts

of capital on public works of this description is evident from the condition of prosperity in which the country was found. These Zemindars were petty princes, each with an independent government of his own ; and for the most part all tanks are attributed to them, and with justice, as it is clear that they understood the science and value of applying their capital to the improvement of their possessions.

24. Comparatively few works of irrigation were probably executed by the Mahomedans in the South of India ; but in the Hyderabad territory, and within a short distance from the capital, and observing no doubt of the use of the Hindoo works, the Kootub Shaly kings, whose government became a rich and powerful one on the subversion of the old Hindoo dynasties, and whose Ministers were chiefly Hindoos, have left some noble works as their memorials.

25. The circumstances of this District, socially and politically, are very different, and I may say, perhaps of the Deccan generally.

26. The soil was productive, and, as far as cereals were concerned, the people in ordinarily good seasons did not absolutely want food ; nor do they now. The monsoon is sufficient for one crop, and black soil, very retentive of moisture, produced jowaree, wheat, &c. as a second crop in the year, without necessity for irrigation. This sufficed for the population ; and irrigation, as a *necessity* to produce means of food, was not required.

27. The Deccan has seen none of those large powerful Zemindars' families which the ancient Hindoos of the South of India show us. There is at least no trace of them, except at Deogurh or Dowlutabad, where a

powerful Chief was found by the Mahomedan invaders ; and around Dowlutabad there are many tanks, the work of that Hindoo dynasty. The rest of the country was held apparently by small Chiefs, neither of wealth or note, and it appears questionable whether there was any control or settled government among them ; even if there had been, the Murathas at no period of history have shown the same amount of intelligence or civilized influence which existed either in the North or South of India. They had no science or literature ; their language was rude and uncultivated, even till lately ; and, even under the Brahmanical rule of the more enlightened Peshwas, their energy was spent in conquest. There was no improvement at home.

28. After the Mahomedan conquest of the Deccan, it was split up into several kingdoms—Gulburgah, Beedur, Beejapoor, and Ahmednuggur. Ferishta's History shows us that the struggles among these rival states were constant and bloody ; and as these districts were the marches of three—Ahmednuggur, Beedur, and Beejapoor—and were alternately held by one and another as might and fortune prevailed, so it may be imagined that they were of use only as frontiers, and their social improvement was impossible. We therefore see military works of much importance in the forts of Nuldroog, Sholapore, Puraindah, and Owsah, erected as garrisons to protect frontiers, but we see no other remains of public or private expenditure, as is evident at any of the capitals ; and we are assured by the history of the period, that no great works could have been probable during the perpetual turmoil and warfare

29. We have no evidence that they formed or maintained any large Hindoo families of Zemindars; and while those who at present exist—Deshmookhs and Deshpandyas—claim to be, and doubtless are, the descendants of ancient families, I doubt by much whether at any period they were ever much better off than they are at present. Had it been so, there would have been ancient remains here, such as large temples, wells, or dwellings, which do not exist.

30. The separate kingdoms of the Deccan were subverted by Aurungzebe, and an unquiet, troublous period ensued. The Murathas wasted and destroyed everywhere, and improved nothing. The large families of Nimbalkurs, and Powars, and Jhadows, of these districts, were collected at Sattara and Poona, or, serving the Moguls, were at feud with their relatives who joined the Muratha confederacy. After the Mogul Emperor came the Soobah of the Deccan, since when this District has been a distant frontier province of the Nizam's Government, and cared for only as far as its revenue was concerned, and utterly neglected in every other particular up to the period of its cession to us.

31. Therefore, while we see no traces of powerful local Hindoo families in ancient times, and of none existing through the earliest period of Mahomedan history (and the Mahomedan occupation is a hardly interrupted period and record of violence and disturbance in this District, in which the frontiers of three rival states were situated), it is impossible to resist the conclusion that local means of improvement were never put to use, and that expensive works of irriga-

tion, where water was not actually wanted to raise food, would be the last thing thought of by local authorities.

32. But I can very well imagine that some officer or local governor, say like myself, who, from seeing their use in other parts of the country, and the comparatively easy means by which natural basins could be converted into tanks, may have begun a series of works, which, by some sudden and unlooked for cause, were interrupted and never completed; and that the province, being a distant one from any capital, was never afterwards cared for.

33. It is on the above grounds that I conceive we have no local evidence of *failure* in works of irrigation, though we have ample evidence of commencements; and I consider that the condition of those tanks which I have described, and the fact of their holding water in a satisfactory manner, is sufficient to encourage a perseverance in improvement, which, I think, will not be without its reward.

34. I should not, however, advocate tanks as means of irrigation, were it possible to turn any of the large rivers to use; but, as I have formerly reported, having examined the Manjera, Seena, and Sherña in many localities, I have seen nothing as yet to hope from them. They run in deep channels, and the ground near their banks lies high, and is undulating and irregular. They are crossed by no high ledges of rock which would serve as points for anicuts. In the monsoon they are subject to heavy floods, which it would require very solid and expensive works to withstand.

it would be most wanted, would be very doubtful in these rivers, and it happens occasionally, as it did last year when only pools remained, that there is no running water in them. With all these disadvantages, a further inspection of these rivers is no doubt necessary, and I will not fail to report any particulars hereafter which may serve to lead to a different conclusion.

35. In conclusion, I have only to state that so far as my experience and judgment will carry me, I shall be most happy to forward any additional particulars on this subject which may be required, or, if any queries are put on any specific points, to reply to them to the best of my ability; and I again beg to repeat that if Government desires to entertain the project of supplying water to the country by an extensive system of tanks—a system which may be extended to other Districts of the same geological formation as this, that is North and South Berar—the personal inspection of the Chief Engineer would be most valuable, either to correct error on my part, or to confirm what I have conceived to be useful and practicable.

I have the honour to be, &c.

(Signed) MEADOWS TAYLOR,
Deputy Commissioner W. D.

*Deputy Commissioner's Office,
Nuldroog, 5th September 1856.*

(True copy)

(Signed) MEADOWS TAYLOR

No. 5199 OF 1856.

TERRITORIAL DEPARTMENT,
REVENUE.

To Captain MEADOWS TAYLOR,
Deputy Commissioner Western Districts.

SIR,—I am directed to communicate to you the thanks of Government for the further Report regarding the expenses attendant on working Wells for irrigational purposes in the Deccan, &c., forwarded with your letter No. 184, dated the 4th instant.

I have the honour to be, &c.

(Signed) H. YOUNG,
Officiating Chief Secretary to Government.

Bombay Castle, 29th December 1856.



MEMORANDUM

ON

CANAL IRRIGATION

IN CONNECTION WITH

THE PERMANENT SETTLEMENT.

BY

A CANAL OFFICER.

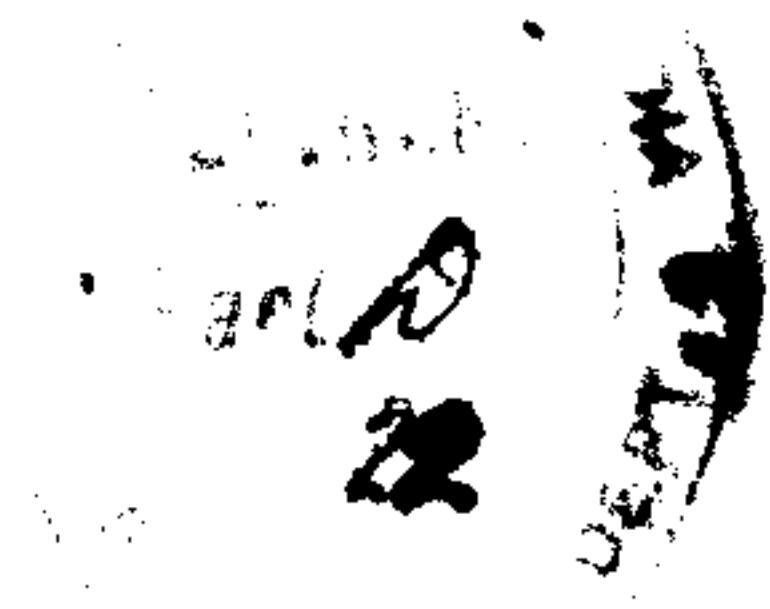
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MDCCCLXIV.



JAMES JOHNSTON, SUPERINTENDENT.



NOTE.

THE following memorandum on the Permanent Settlement of the North Western Provinces, as affected by the Irrigation Department, was drawn up by the writer at the request of the late Colonel Turnbull, Superintendent General of Irrigation, North Western Provinces. Since his decease it has been re-written, and is now printed for private circulation, in the hope that the questions contained therein may receive the full consideration of all Officers of the Irrigation Department.

October 6th, 1864.

C A N A L I R R I G A T I O N
IN CONNECTION WITH
T H E P E R M A N E N T S E T T L E M E N T .

IN paragraph 24 of letter No. 543, dated 8th June 1864, addressed by the Home Secretary to the Government of India, to the Secretary to the Government of the North West Provinces, occur the following remarks regarding the Permanent Settlement of villages under Canal Irrigation or within Canal influence: "Inequality of assessment is also liable to be produced hereafter in other parts by the extension of Irrigation from Canals. It is seldom that the Water Tax taken by the Canal Department equals the full increase of Revenue resulting from the Irrigation. Generally, land so irrigated is rated by the Settlement Officer in a higher ratio than unirrigated land of the same quality. His Excellency in Council is of opinion that, when such irrigation is already enjoyed, to change the practice of Settlement might cause a needless loss of Revenue, and would involve much trouble. Therefore the case of estates receiving Irrigation from Canals, subsequent to Permanent Settlement, need alone be considered, and for this it is prescribed by the Governor General in Council, that revised rates should be imposed by the Canal Department, such as will not be unequal to the total demand on lands similarly irrigated prior to Permanent Settlement. In this

manner, future inequality of assessment will be prevented, and the fair market value be obtained for water supplied from the Canals."

The Suddur Board of Revenue thus comment on this paragraph:—"The instructions as to the Assessment of lands available for Canal irrigation, support the principle already laid down by the Board (*vide* Circular Order No. T, dated 17th August, 1861,) viz.:—that the Revenue is to be assessed as elsewhere on the estimated average rental. The provision for securing higher water rates on tracts brought subsequently to Settlement under the influence of Canals will be the care of the Irrigation Department."

As a Permanent Settlement is about to be conferred on a portion at least, of the North West Provinces, it is as well that it should be considered with reference to the measures that have been adopted for securing the benefits of Irrigation to cultivators. No apology is therefore due for examining the two paragraphs quoted above, as it is believed some good may result from testing the truth or otherwise of the principles laid down by the Government of India, for the guidance of those entrusted with the duty of making the Settlement.

Now these two paragraphs taken together mean simply this. That in assessing a village under Canal Irrigation, the Settlement Officer shall be bound to make a higher Settlement on it, than he would do were the village situate beyond Canal influence. At least, this appears to be the inference to be drawn from the first portion of the Suddur Board's Extract, No. T. In other words, the incidence for the Settlement in any given tract of country will be determined by the presence or absence of Canals. On *prima facie* reasoning it would appear that such an assessment would be the fairest that could be devised, both for the Cultivator and the Government. On close examination it will

be found that such an assessment would be somewhat injudicious, from the insecure foundation on which it would be based.

It is evident that a demand made in perpetuity, and affecting the rights of a large body of proprietors and cultivators to all time, must, to be just and equable, fulfil all the conditions on which it would be founded. It is therefore, equally evident, that should one of those conditions be unfulfilled, or only partially fulfilled, the incidence of the assessment would fall with great severity upon those from whom that assessment would be demanded. Before, then, committing ourselves to the Permanent Settlement as affected by Irrigation from Canals, it would be necessary to examine carefully, at least one of the conditions on which it would be based.

It need hardly be said that that condition is the permanence of the water supply. If it can be shewn that the country or the Government possess any material guarantee for the constant supply of water in all the Canals traversing the former, then all opposition to the scheme of a Permanent Settlement, as laid down by the Supreme Government, and accepted by the Board of Revenue of the North West Provinces, would cease at once. If, on the contrary, this guarantee is wanting, then it is evident that the scheme is defective, and, that should it be carried out, the result would be injury to the people and consequent trouble to the Government.

It is not too much to say that such a guarantee is, from its very nature, almost an impossibility. The supply in any canal is liable to so many fluctuations arising from different causes, some of them entirely beyond control, that it is out of the question attempting to maintain a permanent and unalterable supply. That such is the case, both Sir Proby Cautley and the late Colonel Baird Smith attest to with an earnestness that places it

beyond all doubt. In his "Disquisition on the heads of the Ganges and Jumna Canals," the first named eminent authority thus writes* :—"During heavy droughts I have known the tail of the main trunk of both the Eastern and Western Jumna Canals to be frequently dry. I recollect during one season that on the most urgent application from me to the Superintendent of the Western Jumna Canals, to keep, at any rate, the Ellenborough Tank in the City of Dehli filled with water, he was positively unable to do so." In his elaborately drawn up and exhaustive Report on the famine of 1860, the late Colonel Baird Smith thus writes regarding the action of the Ganges Canal at the most critical part of the year. "Up to the end of July the supply was sufficient, but from the beginning of August to the beginning of October, when the fate of the autumn harvest hung in the balance, and when everywhere beyond the influence of artificial Irrigation, it was being scorched into mere waste, the volume available ranged from 26 to 42 per cent below the needful standard. It is not in the autumn Irrigation that any possible economy of consumption can be of much practical use. The most valuable products of that season must have full supplies of water at short intervals, or they certainly die."

Here then are two high authorities on Irrigation, bearing testimony to the impossibility that exists in the declaring any Canal supply being a Permanent one. And the causes that led to the scanty supply in both the two instances above quoted, are well worthy of examination. In the instance adduced by Sir Proby Cautley, the deficiency at the tails of the Eastern and Western Jumna Canals, is due to excessive consumption on the upper portion of both lines. It is true that Sir Proby is writing more especially with reference to the Navigation on those Canals, but the illustration holds equally good regarding the Irrigation. For

he says,—“so far as my experience goes there are years (and by no means of unfrequent occurrence), when the country is visited by drought, during which no amount of superintendence could protect the water-course heads from the Cultivators, so as to maintain Navigation in an Irrigation Canal.” If this paragraph means anything, it may fairly be taken to mean that there are times when a supply of water cannot be maintained with any certainty whatever in any Canal; nay that some portion of the Canal will be left absolutely dry. In analyzing the illustration adduced from Col. Baird Smith’s Report it will be seen that the Ganges Canal in 1860 did not receive *during the most critical portion of the year* even its average supply. The supply, he tells us, fell short of the standard supply in quantities varying from one-quarter to nearly one-half of what it should have been.

Thus, from the two illustrations above extracted from two different writers, it appears that there are two distinct causes at work rendering a permanent and uniform Canal supply a matter of almost impossibility. They are, excessive consumption and deficient supply. There is yet a third cause remaining that is worthy of investigation.

All Canals and hydraulic works are liable to accidents and consequent injury. The utmost skill and foresight may be unable, and indeed are often unable to guard against serious contingencies arising, and affect materially the safety of the works. In proof of this the Ganges Canal furnishes abundant example. Take for instance, the grand defect of that Canal,—excessive slope of bed. It is a defect candidly acknowledged by the great designer of the Canal, and its evils are patent to all. It is now well known that the action of the water passing down that excessive slope has been to endanger most materially the stability of many of the most important works on the Canal. Nothing but the most anxious and ceaseless care has enabled the Canal to

be kept open so continuously, as it has been, for irrigational purposes. Had one of those works failed or received permanent injury, the results would have been most alarming and widespread. Indeed it is not too much to say that such an event would have materially affected the whole of the country lying on the water-shed of the Gangetic Doab.

Yet in the face of all past experience on the North West Canals, it is gravely proposed to form a Permanent Settlement on villages lying within Canal influence, that shall contain, as one of its elements, an unalterably fixed rate on account of Irrigational advantages that may accrue to them from the near or immediate vicinity of Irrigation Channels. Bearing steadfastly in mind the one great fact of the variability of the Canal supply, it seems impossible that such a measure can work fairly either for Government or popular interests. Setting aside other objections (which will be noticed presently) it would appear that this fact of variability of supply ought to weigh conclusively against the measure under discussion. Indeed it is impossible to discern on what grounds the advisability of the scheme can be said to rest. For in truth the more it is examined the less does it seem to be founded on any solid basis.

Other arguments adverse to the scheme remain to be considered. Supposing it carried out, how are we to deal with the village proprietors or cultivators, if the supply of water has at any time, either partially or entirely failed? In order to comprehend the urgency of this question, it is necessary to understand thoroughly the nature of a Permanent Settlement.

The one great characteristic of such a settlement is the unalterability of the revenue demand. Once the settlement is effected no consideration can or ought to affect it. If one year brings an abundant harvest, the landholder will enjoy his increased profits without any fear of an increased rental. On the other

hand, as Government has agreed once and for ever to waive all rights to a future share in the village returns other than those reserved at the time of the Settlement, so the Government would decline to receive less should the harvest be scanty. By accepting the Permanent Settlement, the landholder has accepted the tenure of his lands for better and for worse.

But how does the case stand if he has accepted his tenure on the understanding that his assessment has been fixed with reference to the capability of his lands receiving Canal Irrigation? Suppose the supply to fail. His lands are at the tail of an Irrigation Channel; the supply has been expended before it reaches them; or the full supply has never entered the Channel. He has abandoned his wells, or they have fallen in from percolation of the Canal water. The rains fail. The Canal is dry. Here are then Contingencies all (at least two of them) beyond his control. How is he to guard against them? How is he to pay the Government demand, the element on which its security rests having failed him? Yet, according to the theory of the Permanent Settlement, he must pay. "The Government demand is fixed and unalterable."

Take, however, a less extreme view of the case of variable or deficient supply. In times of drought, partial or excessive, the demand for water is enormous. It may even be so great as to exceed the utmost capability of any given Canal. The distribution of water then becomes a matter of great difficulty, of such difficulty in fact, as to almost defy the utmost exertions of the Canal authorities. In such a time, it is evident that in order to allow of all benefitting more or less from the supply, it is necessary to close some irrigation channels or heads, in order that lands lying further away from the source of the main Canal may participate in that supply. It is also evident that whenever this closure has to be enforced for any length of time, that some

amount of suffering must exist somewhere. Under a revenue system based upon Canal advantages, the struggle for water will be unmitigated. The utmost efforts to force water down to the lower parts of the country adjacent to the Canal would be unable to cope with this struggle. The supply would be utilised long before it could run its course, and consequently many would be defrauded of what they would consider as their inalienable right.

Now it must be evident to the meanest capacity that in these two cases a great injustice would be inflicted on the people suffering from a scanty supply. It is, however, possible that the sufferer, if he be an educated Native or a European Settler would refer his complaint to a Court of Law for decision. For it is certain that, should the supply fail from whatever cause, a breach of contract would exist on the part of Government. And should the landholder bring his grievance into a Civil Court and obtain a decree in his favour, such a precedent would be established as to cause endless, and possibly successful, litigation against the State.

Having thus analyzed the objections to the proposed system, it only remains to shew what the true course is that should be adopted. A small pamphlet on the "Introduction of the Land Tax into the North West Provinces" has lately been published containing opinions that appear to be unassailable. In page 16 of this pamphlet occur the following remarks. "It seems then trusting to a broken reed to found the Permanent Settlement of the most prosperous and flourishing part of the country upon so dangerous and uncertain a basis. The plan I advocate is that already proposed in 1855 or 1856, by Col. Baird Smith, whilst Superintendent General of Canals, viz;— 'that when artificial Irrigation has been provided at the cost of the State, the land Revenue should be fixed at such rates as would be taken were

the crops dependent on the rains only, or on wells, or on works the exclusive property of the Zemindars themselves, for the water they need, and that in cases of villages irrigated from works the property of Government, any additional charge should be in the form of a water-rate, exhibited in account to the credit of the Irrigation Department,' " In page 23, the writer of the pamphlet goes on to say;—"I mean that we should look entirely to the physical and natural properties and qualities of the soil, and omit any and all special peculiarities arising from situation, such as the vicinity of markets and roads. In making a Permanent Settlement too, the vicinity of indigo factories or cotton screws, or any such like mercantile establishments should not be taken into consideration."

Indeed it is difficult to imagine how any other views than those can be held after due consideration. For it must be considered that whilst the Permanent Settlement is intended to last to all time, every other institution will be in a state of gradual and sure transition. This point has been well remarked on by Mr. Forbes, the present Collector of Meerut. He says (*vide* Appendix No. II of the pamphlet under notice);—"Gurhmooktesur and Shaderah, mentioned by him as large marts, are no longer such; nor is it any satisfaction to those proprietors who may have been highly assessed, by reason of the vicinity of such marts, to be told that others, Bhagput and Ghazeeabad, have arisen in their places. So also many other towns of importance, at the time of the last Settlement, have subsided into comparative insignificance." It is not known whether lands lying in the vicinity of the first named towns were assessed at a higher rate than others at a greater distance, but had they been so, the high assessment, under the thirty years' tenure, was, at least, terminable. But suppose the Permanent Settlement to have been in force when those two marts were flourishing, and that

it had been fixed with reference to their existence, what would be the worth of those lands now, compared with their value then?

There can be no reason why the supply of water should be dealt with after a fashion different to that of any other marketable commodity. Indeed reasoning by analogy, there appear to be sound reasons why it should not be so dealt with. Now what is the action of Gas or Water Companies in England in the selling their products? Take for example, the instance of the Gas Company. It sells its produce by measure. Its rates are fixed at so much per thousand cubic feet of gas consumed. In the summer months, far less gas is consumed than in the winter months. Consequently payments by consumers are less in one season of the year than in another. The gasometer blows up and there is no supply at all. And no supply having been afforded to the consumer, no payments are demanded. The validity of this example appears unquestionable, and why the same procedure should not be followed with respect to the sale of water for irrigational purposes seems almost impossible to imagine. If the example proves anything, it surely proves that the Government should deal with its water supply in exactly the same way as the Gas Company deals with its gas. If there is water and the cultivators use it; payment should be demanded. If there is water, and the cultivators have no use for it by reason of their wells, or by reason of a sufficient rain-fall, then no demand should be made from them. But if there is no water at all, still less should the idea of a demand for payment be entertained. It is certain that in equity, these arguments are beyond the reach of all cavil or dispute. And in consequence it is equally certain that, to make people pay to all time for advantages that may or may not be afforded them, such an injustice would be perpetrated as to cast a great odium upon

the administration that devised and carried out such an ill-advised, and, from a political point of view, dangerous measure.

There need be no difficulty regarding the Settlement of Canal rates. If necessary they could be varied so as to suit the exigencies of times and demand. We know beyond all doubt that the prosperity of the country is increasing, and that consequently the value of wages, labor, and materials will simultaneously increase, causing thereby an increase in the cost of supplying the water. Consequently the rates chargeable on the water might be enhanced, in order to meet the increased cost of supplying it. On the other hand, should the country be suffering from the effects of drought, or disease, or internal commotion, they could be lowered temporarily, till the cause for reducing them had passed away.

With regard to enhancement of rates it would appear politic that it should not be allowed to exceed a certain limit. And the limit should be fixed with regard to the financial condition and prospects of the Canal, and the advantages it may be conferring on the Irrigating community. It may be laid down as a fixed rule, that no rates should be imposed that would bring in a return in excess of 5 per cent., after defrayment of all expenses. This surplus might go to form a reserve fund, from which other Irrigational works might be carried out from time to time, as necessity pointed out.

The object of this little brochure will have been thoroughly attained, if, in the smallest way, it helps towards a reconsideration of the weighty questions brought forward in it. It would appear that the whole of the Canal administration of the North West Provinces, has been looked at from a far too mercantile point of view. It is not from such a point that a wise and far-seeing Ruler would view the matter. It is no question of "returns," and "profits," of "measurements" and "sales," that

would engross his attention. He would take it up in a far different spirit. He would consider it as a matter affecting for good or evil the welfare of millions, and of the millions to follow after them. He would see only that an infinitely great estate had been committed to his charge, and that it would be his bounden duty to maintain it, and improve it to his utmost. To compare great things with small, he would bear in mind how that an English Landholder improves his estate by clearing and draining, without ever dreaming of any direct return resulting from these operations. The returns would be in the increased breadth and thickness of his crops, in the general security of his land, in the well-being and prosperity of his tenants. And it is to those kinds of returns that an Imperial Government should look when devising any great scheme for the improvement or the safety of the country over which it presides. And such returns are sure to follow from the blessing of a Permanent Settlement, unfettered by any question concerning the price or advantages of such a precarious element in it, as the present Canal supply in these Provinces. It is admitted by very many that the blessings of a Permanent Assessment are great. It is admitted by all that the blessings of artificial Irrigation, if natural cannot be obtained, are beyond all dispute. But the Permanent Assessment being for all time, should be based upon conditions not liable to change, amongst which artificial Irrigation is assuredly not one. And unless this question of Irrigation be entirely eliminated from the consideration of the Permanent Assessment, it is impossible that justice can result to the people or satisfaction to the Government.

R E P L Y,

ETC.

IN the preface to his "Disquisition," Sir Proby Cautley says, the main point at issue is "Whether the Ganges Canal "should have been led off above the commencement of the "Northern Doab, &c., or below it." I quite agree that this is *one* main point at issue, and the most important of all the points on which I differ from him, though there are several other extremely important ones. But when he goes on to say that in order to justify his view as to the proper position of the head, "he is compelled to enter into minute "and tedious details regarding the surface contour of the "country, &c.," I am obliged to differ entirely from him. All his long detour in the Himalayas, and on the Jumna, I consider as only calculated to lead away the attention from the real point at issue. The question is—Can a weir be built across a certain river having a certain volume of water, depth, fall per mile, bed, and banks, at a practicable cost? Whatever tends to absorb the attention on other points can have no effect but to keep the truth out of view. We cannot be sufficiently careful in discussions of this kind not to lose sight of the real object of our search. The cuttle-fish, because it cannot run or fight, muddles the water, and walks

away in the darkness which it has produced ; and the case is such with us if we meddle with matters which are not essential to our inquiry ; our prey, which is the truth, escapes us in the confusion, and leaves us groping about with nothing for our pains. I shall endeavour, therefore, so far as is possible, to keep clearly before myself and my readers that one point which is all that we want to know, viz., Whether we can build a weir across the Ganges below the Solani, considering the nature and volume of the river in that neighbourhood ?

All that bears upon the real point in Sir Proby's pamphlet is contained in three or four pages, and the details of levels, &c. he gives, puts the matter as strongly in favour of a weir below the Solani as details can put it. He gives the fall $1\frac{1}{2}$ feet per mile, the extreme rise of the river 11 feet at Futtighur (the nearest point he mentions), the bed sand, and the banks flat alluvium. The current for this fall and depth must be three miles an hour. Now, in Madras we have constructed several weirs with the same bed and banks, with currents of from 4 to $7\frac{1}{2}$ miles an hour, with a rise in floods up to 35 feet, and with falls of $1\frac{1}{8}$, $1\frac{1}{2}$, 2, $3\frac{1}{2}$, and up to 10 feet. Those who are not satisfied with this fact in favour of practicability against argument only, must remain dissatisfied ; for nothing stronger can be said.

Sir Proby Cautley has not given the volume of water, but it is somewhere about $\frac{1}{8}$ of that of one river across which a weir has been built.

As to the other point, "the cutting a canal so that the levels may meet the surface of the Doab," Sir Proby says, "it is a possibility that nobody ever doubted." (p. 90.) In following, therefore, Sir Proby through his "Disquisition," I merely try to meet the cry, which might otherwise

be raised, that I have not answered him, but so far from thinking it really necessary to do so, in order truly to answer him, I insist upon it that a previous tour in the Himalayas and on the Jumna, even in such company, is only calculated to fatigue us, and make us unfit for our work when at length we arrive at the only part which requires to be discussed, viz., the river after it leaves the hills. I can therefore only entreat the reader to keep this point in view, and to observe—for whether a professional or non-professional man, he is equally capable of judging of this argument—that, taking the data Sir Proby Cautley himself has now given us, we cannot possibly be wrong in the conclusion that having executed works of this kind on rivers with much greater volume, depth, current, fall, &c., with entire success, *à fortiori*, we could construct one in this part of the Ganges.

The tendency of Sir Proby Cautley's "Disquisition" is to make non-professional men imagine that the whole matter between us is involved in such a mass of professional details that it is a case of doctors differing, and that consequently it is hopeless for them to attempt to unravel it; my object is to put the subject before them in its true nature, and in the simplest possible form. The case is this: Can we do on the Ganges what we have done elsewhere, in several instances in far more difficult circumstances, the banks and bed of the rivers being exactly the same, but the depth, fall per mile, current, and volume from three to eight times as great. And in saying this, I am not insisting upon any data that Sir Proby Cautley has not acknowledged; I am arguing from the statements of those points given by himself. With this protest, I proceed to notice the statements of Sir Proby's "Disquisition" seriatim.

At page 2 it is said the Madras Engineers build their weirs or Anicuts so that "the flooring of the canal is on the same level as the wasteboard of the Anicut." This is not a correct description. The flooring of the canal is several feet below the top of the Anicut, and in some of the works arrangement is made for raising the Anicut during the dry season by means of iron posts placed at intervals along the top, with grooves at their sides to receive planks, which can then be removed at the approach of the monsoon. Thus the Godavery Anicut was originally built of solid masonry 12 feet high, with iron posts $2\frac{1}{2}$ feet high, and it is now raised to 14 feet with the posts added as before, so that it raises the water in the dry season to $16\frac{1}{2}$ feet above the bed, while the flooring of the canal is 8 feet above the bed of the river, or $8\frac{1}{2}$ feet below the top of the planks. When the planks are not placed, no water goes over the weir till there is 6 feet in the canals; and when they are placed, no water escapes down the river till there is $8\frac{1}{2}$ feet in the canals. Sir Proby Cautley next goes on to say, "*An artificial reservoir is thus obtained in lieu of the natural flow of water into the heads, which is gained by spurs, &c., in the North West.*" This also is incorrect. There is, of course, some water collected above the anicut *in the bed of the river*, but the quantity is quite insignificant, and that entering the canals is only the natural flow of the river, the same as in the North West. In the Godavery, for instance, the canals, when the water is $8\frac{1}{2}$ feet deep in them, can carry off, I believe, with their present breadth, about 1 or $1\frac{1}{4}$ million cubic yards per hour (8,000 or 10,000 cubic feet per second), so that the water detained above the weir would not supply them long. *The water is not stored up by the Anicuts any more than it is by the*

spurs, in the North West. The only difference is, that the weirs give a complete control of the rivers, which the spurs do not, because the latter are liable to be carried away at the moment when they are most wanted. Neither does the next paragraph of the "Disquisition" (page 2) correctly describe the difference between the Madras system and that of the North West. We do not "select the foot of a rapid." Sometimes, as in the Godavery, though not at the foot of a rapid, for there is no rapid within 50 miles of the weir, the broadest and consequently weakest part of the river is chosen, and sometimes, as in the Kistnah, the narrowest part is taken, where the power of the river is greatest. The choice of site simply depends upon where the water can be led off most economically, which again depends upon the supply of materials, &c. The real difference between the two systems principally consists—1st, in making a permanent complete weir, instead of partial and temporary spurs; and 2nd, in leading off the water at as low a level, and consequently bringing it from as short a distance, as the land absolutely requires. We should not have thought of going to a point hundreds of miles distant from the land to be irrigated, when it could be got near at hand. These are the real differences between the two systems; and the real cause why the works in Madras, though still unfinished, are returning from 20 to 70 per cent. in actual profits to Government; while the Ganges works, though they have now been in hand some 20 years, are not yet returning a fair interest. Not that I think the latter would not return good interest, perhaps 10 per cent., if they were only completed even upon the original plan, defective as it was. But most assuredly, had these works been originally planned and executed upon the principles of the

Madras works, they would, long before the sum they have already cost was expended, have been yielding at least as ample a profit as the Madras works. If it is still said this is all boasting, I cannot help it. It is the actual state of the case, and the public service absolutely requires that the matter should be clearly and distinctly shown as it is, in order that the Government and Companies may be guided respecting the planning of future works. The two systems have been tried, and the results are palpable; and all we have to do is to make the best use we can of experience dearly purchased. It is of no use at all, nay, it is treason to India, to screen from view the facts of the case. At this moment the vast results of the Madras works are the grand support of the argument for regulating the waters of India, for (as Ruskin so beautifully describes it) converting that "which now overwhelms the plain, and poisons the wind, its breath pestilence and its work famine," into that which, "rightly directed, flows in soft irrigation from field to field, purifying the air, giving food to man and beast, and *carrying their burdens for them on its bosom.*" And it is equally a fact, that the want of returns in money from the Ganges works, is the grand argument of the opponents of these beneficent operations. This was *the* objection raised by Mr. Laing, when I urged upon his attention, as the very first point in the financial question, this regulation of the waters, and it is *the* objection in the mouths of every one of our opponents—"how-
 ever beneficial these works are, we cannot afford them; we have sunk 2½ millions in the Ganges canal, and it is not even yielding the ordinary interest of money." This is the actual state of things, and at whatever cost of personal feelings, the public interests require an answer to the question—Are the principles which have resulted so well in

Madras applicable to the vast plains of India generally, and especially to the principal plain, that of the Ganges? Upon the correct solution of this question depends nothing less than whether we can extend the regulation of its waters to India generally, or whether 19-20ths of that country must still remain subject to drought and flood, and their consequents, oppressive taxes, disease, famine, and discontent with our rule, as well as isolation from the markets of the world, from the prohibitory cost of land carriage. This is not a discussion between two insignificant individuals, but an investigation into the value of two systems; which involves in its results, if rightly dealt with, the wealth of India, and consequently of the whole empire, in an extraordinary degree.

Further on the same page Sir Proby Cautley repeats his former assertion, that "the physical conditions of the river systems" (that of Madras and that of the North West) "in the two cases are in some important respects widely different, as will be shown in the sequel;" yet in the sequel he mentions no one important particular in which they differ, excepting that the southern rivers are very far larger. Their beds are the same, their banks are the same; in all other respects we have had in Madras to deal with far greater difficulties, greater depths, greater volume, greater currents, and greater depression below the country.

From page 2 to page 9 Sir Proby Cautley speaks of the passage of the Jumna and Ganges among the Himalayas, of the fall of the rain in the Doab, and of the flooding of the Jumna; but this part contains nothing which in the least affects the question at issue, viz., the practicability of building a weir across the Ganges after it leaves the hills; the whole tendency of it is not to throw light upon, but to hide the truth we are in search of.

At page 9 Sir Proby Cautley gives the rise of the river at Futtighur at under 11 feet as the highest in 11 years. How very strange it seems that it should not have struck him while recording this, that as we have mastered rivers with a rise of 30 and 35 feet like the Godavery and the Kistnah, he was registering a fact which was altogether an argument on our side! The Godavery Weir is 14 feet high, the floor of the lock at the head of the Canal is 8 feet above the deep bed of the river, and the lock walls are 22 feet high. At the Kistnah the weir is 16 feet high, the floor of the lock is 10 feet above the summer level of the water, and *forty-eight feet* above the deep bed, and the lock walls are 27 feet high. The whole depth of water from the deep bed of the river to the level of flood is *72 feet*. What an insignificant work in comparison with these would be the Ganges Weir, having only a total depth of about 13 feet to deal with. Supposing the floor of the lock was 3 feet above the deep bed, the weir itself might be 8 feet high, and the lock walls 11 feet high. It would, in fact, be a Lilliputian work, especially when we consider that the body of water is about $\frac{1}{6}$ and $\frac{1}{8}$ of those of the others. Now if after successfully mastering those southern rivers, Engineers were to undertake to throw dams across others that had a rise of 50 feet, and a volume 50 times that of the Ganges at Futtighur, it would not be presumption, but only boldness such as every Engineer ought to be prepared to show; so that we might fairly argue that our next attempts might be on the Yangtze and Yellow rivers, instead of our being gravely warned not to think of encountering this (at the point named) petty Ganges stream, with its fall of $1\frac{1}{2}$ feet, its current of 3 miles, its depth of about 13 feet, and its volume of 25 million of cubic yards.

Sir Proby Cautley then speaks of the *suddenness* of the floods in the Ganges; but this in no way affects such a work; it is a matter of perfect indifference to a solid masonry weir whether the river rises 1 foot or 10 feet in an hour. He then goes on to speak of the declivity at *the present canal heads* being from 16 to 20 and 30 feet per mile. This, if it bears upon the question at all, can only tend to show that it would have been better to begin lower down, where the declivity is only $1\frac{1}{2}$ feet.

✓ Sir Proby Cautley next speaks of sudden rises of the river in the dry season placing unfinished works in the beds of the river in jeopardy. This is certainly a disadvantage, but we have just the same in Madras; we have had bridges entirely destroyed, when nearly completed, by these irregular floods. But such contingencies ought not to prevent an Engineer from attempting anything. We have had several accidents in this way, which have caused extra expense, but they have not prevented the works being completed.

In some of the pages which follow the 12th, Sir Proby Cautley speaks of the stone of the neighbourhood. He says that in general it is unfit for the works; but to this I can only reply, as I said before, that I saw excellent stone in Hurdwar myself, and I need not pretend to doubt whether more could be found where it came from. That the stone generally is soft does not the least affect the question, which is, whether there is hard stone in the neighbourhood. He speaks also of the masses of old masonry at Badshapoor, which must have lasted a long time. Sir Proby then finds fault with me for wondering that the river pebbles had not been generally used, and is surprised "at my persisting in my assertion after he had told me I was mistaken." But I really must believe my own eyes. I

saw the whole of the great works near the head of the canal, and I did not see one pebble used in them. I therefore could not possibly be wrong in asserting that pebbles were not *generally* used. Sir Proby Cautley says that they were used in some of the foundations, but this does not contradict my assertion. I never denied that pebbles had been used at all. I said "it must have been in a very small proportion, for I saw no pebble masonry." Sir Proby Cautley proceeds to argue for several pages that the Sewalik sandstone is unfit for such works, but no volumes of argument can convince me against my own senses. When he says that I confuse the *soft* sandstone of the Sewalik Hills with the old sandstone rock of Southern India, he begs the whole question by adding a word which I never used. What I compared with the Southern stone was not the "soft" sandstone of the Sewalik Hills, but the *hard* sandstone of the same locality, and this makes the whole difference. I did not say that the soft stone would do for the apron of the weir, but the excellent hard stone which I saw in Hurdwar. Sir Proby does not say what the cost of this stone would be, but I am quite sure houses would not be built of it if the cost were such as to make it impossible for us to use it for the apron of the weir; and there is another kind, a conglomerate, which the officers stated would cost 27s. a cubic yard, a cost not at all excessive for such work.

In the note at page 23 Sir Proby Cautley objects to my using the expression "the Delta" between the Ganges and Jumna. I have no doubt that it was merely a mistake in writing for the "Doab." It is a mere trifle, however, and cannot in the slightest degree affect the discussion. He then proceeds to speak of the difference between Delta

rivers which run upon the ridge of the country, and rivers in the upper part of their course which run in "a trough,"—that is, in the lowest part of the tract. This may be said to be a true description; but it does not affect the question, because our Madras works are not only constructed in the former circumstances, but in the latter also. Several of our Weirs are constructed in rivers to which the country slopes. The Toombuddra works, for instance, as I have stated in my former paper, lead the water 70 miles, and to a height of 150 feet above the river, before they command the country. One of the Godavery Canals is cut 12 or 14 miles before it commands the land, and begins to irrigate. At the Upper Coleroon Anicut also the ground slopes *towards* the river, and the same on one side at the Lower Coleroon Anicut.

Sir Proby Cautley next describes the narrow flat ground on each side of the Ganges, called the Khadir, with the high ground of the Doab skirting it; and then proceeds to state that this is the distinction between the Delta rivers of Madras and the rivers of the North West running "in a trough." My reply to this is, 1st, that whether the river is a proper Delta river or not does not touch the question of the practicability of constructing a weir. We must keep the two points distinct, because they have nothing to do with each other—viz., the practicability of building a weir, and that of leading the water on to the face of the land. Whether the river runs on the highest or the lowest part of the tract of the country does not make it more or less difficult to build a weir; *that* depends upon the nature of the bed and banks, and the depth, volume, current, and fall per mile of the water. The length or stability of the weir cannot be the least affected by the height of the adjoining

country, or by the fact whether the canals have to be cut 5 miles or 50 before they begin to irrigate. The difficulty and cost of the weir depend upon the things mentioned above; those of the canals upon the height of the land above the river, the slope of the country in the direction of the course of the river, and the nature of the ground to be cut through—that is, whether flat or undulating, &c.; whether rock, earth, sand, &c. 2nd. As I have shown before, our Madras works are by no means confined to Delta regions. There are many Anicuts built on rivers above the Deltas, or which have no Deltas.

At page 29 Sir Proby Cautley goes on to say, that “in Delta regions the rivers in severe floods find relief by lateral inundation; but in trough regions, action being limited to a comparatively narrow channel beyond which the water cannot escape, the torrent within those limits operates with unrestrained violence.”

This is evidently, in Sir Proby Cautley's view, *the* point of his disquisition, and forms in his mind a conclusive argument against the construction of an Anicut below the Solani. But I reply, that in Deltas, as out of Deltas, the weirs are constructed to allow *the whole of the flood waters passing over them*. In the case of the Coleroon Anicuts, which have now been in operation 28 years, the whole of the floods have always passed over them, and all the other works are constructed on the same principle. If they are not sufficient to pass off the heaviest floods, they are defective. We may have, of course, such floods as we have no account of in times past, and which may do great mischief; but these would occur in the absence of an Anicut, and their effect would not be increased by its construction; and we can construct no hydraulic works at all if we are not to work

within some limits, for whatever the floods have been in times past, it is certain that it is quite possible that double that quantity might pass down the river. It really seems a work of supererogation to repeat here anything bearing upon the effect of an Anicut during the period of flood in the river, so well ought that to be known to professional men; but in compliance with a recommendation made to me, I must state for the information of non-professional men, that during such period the water is only raised in a trifling degree, and in most cases *no appreciable difference is produced by an Anicut in the flow of a river*, and no efflux of any moment is created by the Anicut. During floods in the Godavery River it is impossible to distinguish from the rest of the flow the spot covering the Anicut.

*Sir Proby Cautley continues to argue for the necessity for very different treatment for "Deltaic regions" and "trough regions." But all this only tends to obscure the truth. Delta works ought to be planned *to carry off extreme floods* just the same as other works; and further, we have abundance of works on both kinds of rivers. All that Sir Proby Cautley says, implies both that there are no Anicuts in Madras out of the Deltas, and also that the Delta works are not constructed to carry off the whole of the water in floods; but as neither of these is the case, all he says on this subject is nothing to the point. He further says: "Works of the same description and detail will not answer for both. There may be a question as to such being at all applicable to both cases; but, at any rate, when calculating estimates of cost, it would be dangerous to place them in the same category as to extent and proportions." But who ever dreamt of such a thing? What Engineer ever thought of planning a work that should suit

two different rivers? Did I propose to construct a work for such a comparatively insignificant river as the Ganges at Sookurtal, of the same "extent and proportion" as for the Godavery or Kistnah? for a river of 13 feet deep, current of 3 miles, and volume of 25 million of cubic yards, as for one of 30 or of 70 feet deep, of a current of 4 or of $7\frac{1}{2}$ miles, of a volume of 160 or of 200 million cubic yards? I certainly proposed to construct a work proportional to its peculiar locality, and should no more think of putting on the Ganges such gigantic works as we have had to construct in the South, than I should think of dressing a little boy in his father's clothes.

Sir Proby Cautley then describes the Ganges Khadir, which is exactly the same as our Delta land, so far as it extends—that is, for a few miles on each side of the river. Nothing can be more simple than to carry the canals leading from the weir through this flat tract, which is partly below and partly above the extreme flood level. I may mention here that the most remarkable point in the river, as described in the "Disquisition," is the extremely small range of the flood level. At Futtighur Sir Proby Cautley gives the average of 11 years as $9\frac{1}{4}$ feet, and the highest flood $10\frac{3}{4}$, so that no land that is not generally flooded can be more than $1\frac{1}{2}$ feet under water in an extreme flood.

The pages which follow, to the 45th, are taken up with the Jumna, with which we have nothing to do. Sir Proby Cautley then speaks of the Ganges works, and of the arrangements that were made for sanitary purposes, and implies that I treated with indifference evils of the greatest magnitude; that is, that I did not provide for sanitary requirements. Not a word that I said implied that I did not intend to provide for them. The sanitary arrangements have nothing in the

world to do with the site of the weir. The canals may be led close to, or far from, the cantonments and cities, whether the weir is at Hurdwar or Sookurtal. The only thing I said on the subject of sanitary provision was, that in cutting the Ganges Canal deep in order to prevent the water keeping the neighbouring lands in a wet state, its Engineers produced the very effect they intended to prevent, because they cut through the water-tight stratum, and let the water into the sands below, which carry it all through the country. There can be no question about this, and it was first pointed out to me by Colonel Baird Smith himself. But when Sir Proby Cautley insinuates that my plans would prevent the necessary sanitary arrangements, he insinuates what there is not the slightest ground for; for, on the contrary, those plans would provide a *perfect system of "drainage,"* and thus necessarily render the locality free from stagnant pools and malaria.

Sir Proby Cautley next speaks of the navigation, and again states that it was quite a secondary object; but he does not try to answer one of the arguments in my former papers, intended to prove that so dealing with navigation in the projection of such a work was a mistake. He speaks here of canals as being accessory to railways, which also shows how entirely he misapprehends the case of transit. I have shown that exceedingly cheap carriage, such as nothing but water can give, is absolutely essential, and that in America from 95 to 99 per cent. of the goods are carried by water; so that any Engineer who treats navigation as a secondary and unimportant matter, makes the greatest possible mistake. India must either have water-carriage, or 9/10ths of its traffic must be prevented. He says, "It is doubtful how far irrigation and navigation can be carried

on conjointly, without one clashing with the other." But what avails such an assertion in the face of the fact that *for 14 years the whole traffic of the Godavery Delta has been carried on the Irrigation Canals?* He then argues from the failure of the Ganges and Jumna Canals to secure navigation that it is impracticable. The Engineers have not provided properly for the navigation, and then argue from that that it is impracticable—just as they argue from their not having built a weir, that such a structure cannot be made. And exactly in the same way they might argue that, because they have not provided for the effective supply of the canal with water, because they have neglected to construct the most essential work—a permanent and complete weir at the head—therefore canals from rivers cannot be securely supplied with water. The answer is, that where the navigation has been attended to, there it is in most successful operation. The irrigation without it would have been deprived of half its value. The last Madras administration report states that immediately on the main Irrigation Canal from the Kistnah being completed, the lock at the lower end had to be worked day and night to meet the great traffic; and the last return of the Godavery Main Canal I have seen gave 5250 boats passing in three months, or at the rate of 21,000 per annum, besides rafts. Sir Proby Cautley attempts no arguments against these facts; and, I am entitled to ask, how could he? He merely repeats his own bare assertion. Sir Proby Cautley again, as in former papers, speaks of their not being able to *afford* water for navigation; but he has still no answer to my arguments, that the navigation takes no water from the irrigation, except the trifling quantity required for lockage, which is quite insignificant; nor does he say a word about the enormous importance of the navigation

in time of famine. I have shown by Colonel Baird Smith's testimony, that at that time the importance of water-carriage to carry food from other districts is far greater than that of the local irrigation. But he cannot reply to these arguments; and his silence will bear only one interpretation—that they are decisive, and that to make the navigation a matter of so little importance that it was left in a perfectly ineffective state, after expending many thousands of pounds in locks, &c., was a fundamental mistake, and the greatest injury to the country.

At page 49, Sir Proby writes—"So far as my experience goes, there are years (and by no means of unfrequent occurrence) when the country is visited by drought, during which no amount of superintendence could protect the water-course heads from the cultivators so as to maintain navigation in an irrigation canal." First, who cannot see that to argue against a general line of proceeding by some special and occasional circumstance is false arguing? Suppose we were to argue in this manner in respect of police matters, and to say as to protecting the country in general, it is out of the question, for there are times when the country is visited by drought, when no amount of superintendence could protect them; for a starving multitude would plunder the bazaars in spite of any police. Are we never to have rule and order, because there may be times when all rule and order is overborne? And so, are we not to make use of the navigation for nine years out of ten, because there is a possibility that in the tenth we may not be able to use it for a month or two? The Erie Canal, which conveys several million tons a year from the lakes to New York, does not suffer from a mere possibility of interruption once in many years; but is stopped for five months in every year by frost.

And *were it true* that the navigation could not be maintained for a few months at intervals of several years, it is not the slightest argument against it. The railways in England are occasionally stopped by snow; but who dreams of their being given up on that account? But, secondly, at that very time of drought the navigation is of far greater importance than irrigation, as Colonel Smith shows; and to allow the importation of millions of tons of food into the famine districts to be prevented by the upper cultivators emptying the canal and appropriating all the water, leaving none for the lower ones, would not of course be permitted, whatever force it required; the navigation at such a time is of such vital importance that it must be protected, whatever else is allowed. But rules securing *an impartial use of the water for irrigation along the whole line of canal* would be sufficient for that purpose, for the navigation could only be interrupted by allowing the use of the whole of the water in irrigating the lands adjoining the upper part of the canal, and depriving those situated lower down of all irrigation whatever.

At page 50, Sir Proby Cautley repeats his assertion that "Navigation should be subservient to the interests of the agriculturist, and that so long as there is water *running* in the canal, sufficient for the passage of the boats, boats may be used upon it; when the fields require the water for irrigation, the passage for boats must cease;" but he has not a word to answer to the facts that I have brought forward. In the Godavéry Delta we require every drop of water for irrigation in the dry season, and five times as much as we have, and we *use all we have*; but this does not prevent the navigation going on every day of the year. In the face of this fact, what can be the use of continuing

as if the water must be used for one or the other? The water is not injured for irrigation by boats passing through it. I have pointed out the works that are wanted to make the canals navigable to their lower end during the dry season—viz., to reduce the last part of the canals to levels by locks: this is all that is required. No *running* water is required for the navigation. I have pointed this out repeatedly, and the navigation of the Godavery Canals for fourteen years, throughout the year, shows that it is completely effective; and no attempt is made to set aside this argument, nor is the least allusion made to it in the pamphlet under reply, and there can be no question that Sir Proby Cautley would have answered it if he could.

The pages following to the 55th are taken up with accounts of the Jumna Canals, which have nothing to do with the question of our constructing a weir on the Ganges. At page 55, Sir Proby says that attempts were made by driving piles, &c., for a new head to the Jumna Canal during the dry season of 1827-28, near Kurnal, but that all was swept away by the freshes. But he does not know whether the Engineer was trying to throw a dam across the channel, or to establish a head with temporary bunds, &c., so that it appears that it is not certain that it was even attempted to form a permanent weir. From the mention of piles it seems pretty certain that the Engineer did not understand the case if he was attempting to build a weir.

✓ At page 56, Sir Proby Cautley says: "Is it at all surprising that this ill success warned the Ganges Engineers against attempting to take a head from the sandy tracts of the Ganges?" I do not know that it is surprising. It seems clear that at that time they did not know how to build a weir in such a situation, but having proved by numerous successful works in far more difficult rivers, that we do now

know how to construct such works, we ought to take advantage of that knowledge. At page 56, Sir Proby again asserts that though it is possible to build a weir across the rivers in Madras, it is impossible to do so on the Ganges; but again he does not bring forward a single argument to show us why what has been done on one river cannot be done on another having the same bed and banks, but with a much less fall, depth, and volume. He again brings in the word "trough," but I have shown that the depth of the river below the land to be watered, has nothing whatever to do with the construction of the weir, but only with the length of canal necessary to lead the water out upon the plains.

I am sure Sir Proby Cautley is quite mistaken in imagining that it is only by actual attempt at construction that, in the diametrically opposite views taken by himself and me, the question at issue can be determined. By all unprejudiced men, whether Engineers or not, the matter is already determined that after the great works in Madras, this petty work on the Ganges can certainly be constructed without any serious difficulty.

Sir Proby Cautley further says, "He, no doubt, judging from the tone of his pamphlet, considers that I am as ignorant and without experience, &c." It is surely too much to expect that I should consider him a man of experience in these matters, when I know that he has never built or attempted to build a weir, and never seen those that have been built. He certainly is ignorant and inexperienced on this point. There can be no possible question about this. The utmost that Sir Proby Cautley can say is, "I don't think;" but from thirty years actual experience it is no presumption in me to say "I know." His being per-

suaded that my estimates are worthless and visionary does not the least affect the case. They are calculated solely from the actual cost of several works, built on exactly similar rivers, but many times as large, and it is impossible that better grounds for estimates could exist; but it is not a question of cost at all that we are discussing. The Ganges Canal is confessedly in a state which affords good ground for alarm, and the important point now to be decided is whether remedies based upon, and in accordance with, the plan that has admittedly failed, or those belonging to a tested and successful system, and, I add, incontrovertibly applicable to the case, are to be had recourse to.

In pages 59 and 60, Sir Proby Cautley continues to argue that my experience is on rivers essentially different, because they have such small slopes. And he gives the following as the slopes of the Madras rivers:—

Cauvery	3½ feet
Kistnah	1 foot
Godavery	5 inches

Why did he not add the Ganges below the Solani thus?—

Ganges	1½ feet
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or less than half that of the river at the first Anicut built. And when I mention the Pallaur with a slope of about 10 feet, he disposes of it by means of one word, “this is an *exceptional case*.” In his former pamphlet, he says “the Ganges has a slope of bed far beyond its Madras compeers—THIS SLOPE MAKES ALL THE DIFFERENCE.” And here *his own figures* show that, our first large weir was on a river with double the slope of the Ganges. In the above statement of the slopes of the Kistnah and Godavery, how-

ever, Sir Proby Cautley is wrong. The actual slopes at the sites of the Anicuts of our Madras rivers are as follows:—

Upper Coleroon* Anicut.	. . . . .	3½ feet
Lower ditto	. . . . .	2 „
Pennair	. . . . .	3 „
Godavery	. . . . .	1½ „
Kistnah	. . . . .	1½ „
And that of the Ganges	. . . . .	1½ „ according

to Sir Proby's pamphlet, in the part of the river below the Solani; so that if the "slope makes all the difference," out of all our Anicuts, we have only one that is less than that of the Ganges, at the site in question, and that in a degree quite insignificant. But in point of fact this idea about the slope is wrong—the fancy of a man who has had no actual experience;—the slope does not make all the difference, for we find no great difference in establishing a weir across a river with a fall of 1 foot, and that across a river with a fall of 3 feet or 10 feet. No extraordinary precautions are taken in the greater falls.

Sir Proby Cautley says that they have already built *dams and weirs* over beds of sand of unlimited depth in carrying the canal across streams having falls of 9½, 11½, and 8 feet a mile. To this I reply, then why, if "the slope makes all the difference," not build a weir across the Ganges with a fall of only 1½ feet. But these dams are not what we mean by weirs or Anicuts. Our works (and what I proposed to build across the Ganges) are permanent high weirs, from 6 to 16 feet high, with such a fall of water over them. These dams on the line of the canal are low ones, and the

* There is no Anicut across the Capvery; the Anicut is across the head of the Coleroon, where the two separate.

water is raised by moveable gates when there are freshes in those streams.

The following pages, to the 68th, are about the drainage streams of the Doab, which have nothing to do with our present question. At page 69, Sir Proby undertakes to show “not only how obviously advantageous it was in every point of view to select that particular spot (Hurdwar) as the site of the canal head, but how impracticable it would have been to have gained the required object otherwise.” I am sure I have said amply sufficient to show that to do this is a great undertaking; but I must, though at the expense of great repetition, follow Sir Proby through this part of his “Disquisition” also. He premises, however, “1st, That so far as the levels alone were concerned, nobody ever doubted that they offered any impediment.” This point, therefore, is granted, and nothing remains but the question of the practicability of building the weir. “2nd, He also premises that it is only a question of economy whether a weir here is practicable,” so that there is no question also about the possibility of building a weir. He proceeds to state his approval of the construction of a permanent weir at Hurdwar, and he considers that it will be comparatively easily built from the foundations being laid in the boulder bed, and from the supply of boulders for the superstructure. Upon these points I can state with certainty that there is no advantage in a boulder bed for foundations, because we have found that, excepting solid rock where no foundations have to be laid at all, sand is the best possible foundation, if only wells are used. We never have the slightest difficulty with our foundations, and they are extremely cheap, as may be judged from the cost of the Godavery Anicut, 200 R's, or £20 per lineal yard, and this

includes all the locks and sluices, temporary embankments, apparatus, &c. This is for a solid masonry dam 12 feet high, 48 feet thick, with a loose stone apron of 20 yards broad. The cost of the foundations was, in fact, quite insignificant. Many thousand bridges, aqueducts, weirs, sluices, &c., have thus been built on these well foundations in sand, so that we have abundant proof of the cheapness and excellence of the foundations in sand. There could, therefore, be no possible advantage in a boulder bed over a sandy one in this respect.

In pages 71 and 77, Sir Proby Cautley gives us the slopes of the country and of the river, with the height of the watershed, or highest point of the Doab; and of the Futtighur branch of the canal above the bed of the river at various points. They show, as I stated in my former pamphlet, that the level of the land along the Futtighur branch, above the low level of the main river (at the highest point on the river which is given in his table, viz., 45 miles below the head of the Futtighur branch) is 47 feet; and at the next point given, viz., 65 miles, it is 28 feet. This agrees well enough with the information given me on the spot, that at two points which had been taken it was 40 feet. But Sir Proby says again here, that nobody can doubt the possibility of making a cut from the rivers so as to meet the surface of the country; so that, as I have said before, this point is conceded. I am, however, unable to make out the meaning of the remainder of this paragraph, where he says, "I hope I have, though at the expense of some trouble, satisfied him on this point." He cannot mean that he hopes he has satisfied me that it cannot be done, because he had just said nobody doubts it can; nor has he anywhere mentioned any obstacles to its

being done. He has given me no information here which I had not before. I am obliged to leave this paragraph, therefore, as I find it, for I really cannot imagine what it means.

At page 78, he gives the nature of the soil on the high bank, above the Khadir, as partly sand, partly slabs of Kunkur, and partly good soil, and says, "It would, on the line marked by him, give him sand as the bed of his canal." I have no great objection to sand for the bed of my canal; one of the main canals of the Godavery, for some miles from the weir, is a small branch of the river which we stole, and the bed is nothing but the loosest sand. There is no objection to sand *if the current does not exceed 3000 yards per hour*. With this current, or less, the canal puddles itself, and becomes as water-tight as if it were lined with butter. When we widened the canal above mentioned, we cut close to the water's side to a depth below the water's surface of 4 or 5 feet in loose sand, and found it as dry as dust—not a drop of water was soaking through the bottom or sides of the canal. Sand is only objectionable when you have a current of 5000 or 6000 yards an hour, which is sufficient to scour the bed as it does in the rivers. It is very probable that the branch called the old Ganges, below Sookurtal, would be used just in the same way we used that on the Godavery, and that a great deal of cost would thus be saved.

Sir Proby Cautley proceeds to speak of the weir. He says, "He selects a point near Sookurtal, and draws a line thence to Newarrie on the main canal." In this I only shewed the line which his own levels prove to be practicable. I did not attempt to *decide* upon the precise point for the weir, which could only be decided after much examination. What I had to do was, not to give an actual

projection and estimate in detail, but merely to show that I had ample grounds for deciding upon the practicability of the plan of leading off the water below all the heavy drainage of the Sewaliks, and to point out the general features of my project. All the details, of course, could only be settled by close and careful examination of the ground by an Engineer experienced in the construction of weirs.

Sir Proby Cautley next shews the objections to such a weir, but as they all arise from things that he has himself imagined, but which I have not proposed, they might as well have been omitted. I had supposed *the summer or low level* of the water raised 10 feet." To this he is pleased to add, first, 5 feet, and then 3 feet more, and thus to make the surface of water in floods 18 feet above the *low level*, while the *present level* of the floods is only 11 feet. There is not a word in my paper about thus raising the flood level of the river, nor did such a thing ever enter my head, so that all the awful consequences here particularized of inundation, fever, &c., are entirely imaginary. In the first place, I did not pretend that I had determined the precise height of the weir, which could not be determined without detailed examination. But suppose this 10 feet had been decided upon, probably the top of the Anicut would be 7 or 8 feet above the low level, and two or three feet of posts and planks would complete the height. The level of the floor of the canal might thus be 4 or 5 feet above the low level, so that when the planks were up 5 or 6 feet of water could enter the canal. The top of the masonry would thus be 3 or 4 feet *below the present flood level*, and the Anicut might be placed where it would be sufficiently long to provide for *the discharge of the whole of the flood water, without raising the surface more than probably a few*

inches, instead of 7 feet as imagined by Sir Proby Cautley. This objection was exactly the sort of thing we had to encounter when the Godavery Anicut was proposed. "A weir 12 feet high! Why, the town of Rajahmundry is only a few feet above the present flood level, the whole town will be swept away." BUT THE RIVER IS NOT RAISED A SINGLE INCH IN FLOODS. YOU MAY RUN OVER IT IN A BOAT WITHOUT THE SLIGHTEST INDICATION OF THERE BEING A WEIR UNDERNEATH. I have no intention of inundating a single square mile of country by an Anicut across the Ganges, and all who have witnessed the passage of a flood over an Anicut will readily understand and avouch that none would be so inundated.

Sir Proby Cautley next proceeds to warn me of the consequences of building weirs, and gravely to inform me that the tendency of the river at all times, when subjected to being interfered with by dams, especially in floods, is to "undermine the foundation in front, &c." This is like my taking an old army-surgeon under instruction, and kindly pointing out to him the tendency of cutting off a limb to produce such and such results. One would suppose that I had yet to build my first Anicut, and that Sir Proby had been employed for 35 years in superintending, planning, and executing such works. How very extraordinary it seems that it should not occur to him, that no talents can more than make amends for the long actual experience I have had, during which I have seen so many accidents, partial failures, and ultimate successes. In the same way he proceeds as gravely to tell us, that I estimate such an Anicut at 75,000*l.*, but that he thinks that it would exceed the cost of all his works from Hurdwar to Newarrie—that is, somewhere about a million, or ten times the cost of either the Godavery or the Kistnah Anicuts thrown across rivers

of 6 or 8 times the magnitude of the Ganges, so that for the quantity of water to be provided for, he estimates the cost at 60 or 80 times the actual cost of those works. My estimate is not a mere guess—it is based on the actual cost of similar works. But I must be again so boastful as to ask, who is best able to judge of the cost of such a work, an officer who has had a hand in the construction of many great works of the kind, or one who has never even seen one, and clearly does not understand the system of which they form a part?

At page 81, he speaks of the want of building materials at Sookurtal and below. This is a real difficulty, and would certainly make it more expensive than if the materials were at hand, but I have allowed for this by estimating the cost of the works at three or four times those of the Godavery and Kistnah, allowing for the difference in the volume of water. But, further, having now both the canal and the river, no doubt much of the materials would be brought at a small cost in carriage by those lines of water transit from where they are found.

Having, by an inundation of his own creating, and of which I am entirely innocent, laid the country waste with fever, and swept away multitudes of towns and villages, Sir Proby Cautley next proceeds, at page 82, to say—"the fact is, that Sir A. Cotton, with his Madras experience, looks on sanitary interference as totally uncalled for." This is a singular sort of fact, when I have never written a word that implied any such thing. As I have said, my plans leave all the arrangements for sanitary precautions as they were. Whether the Anicut is at Hurdwar or lower down, the canals can be carried clear of cities, and a thorough system of drainage may, and I say ought to be established, so as to prevent the collection of stagnant

water. This charge is pure invention, for which Sir Proby has not the least foundation. He proceeds to say how Colonel Baird Smith told him that in Madras we were perfectly indifferent to sanitary discipline. To this I reply, first, that in Madras we don't fight with ghosts. So far from having fever connected with our irrigation, our irrigated districts are the healthiest tracts in the country. Tanjore, which is one sheet of irrigation, the whole tract entirely under rice cultivation from the coast to the Upper Coleroon Anicut, nearly 100 miles, is entirely free from fever or any other epidemic. *As a matter of course, the perfect drainage which is carried on in connexion with the irrigation does not tend to produce fever, but the contrary.* It was perfectly natural for Colonel Smith, who had been so worried with fever in the North West, to be surprised at hearing nothing about it in Madras; and of course he did not, in the few days he was in Madras, realize the fact that we had no fever to contend with; but if he meant to say that we executed the works in such a way as was calculated to produce fever, he certainly was quite wrong, for *no stagnant water is allowed anywhere.* It is very probable that, visiting the works as he did while they were under execution, he saw many things in an imperfect state; but this must be so. A man might as well find fault with the heaps of materials and rubbish about an unfinished building. But this remark of Colonel Smith's about fever calls for the observation, how careful we should be in judging from people's "first impressions." Colonel Smith comes so brimful of the idea of a connexion between fever and irrigation that he cannot separate them. Everybody would have told him that whatever connexion there might be between the two things in the North West, where irrigation works are imperfectly understood and imperfectly executed, there was no

such thing in our Deltas. But no doubt he thought if there were not, there ought to have been, and that it should not be allowed that evils produced by irrigation imperfectly supplied in Bengal should not exist in the subordinate Presidency, just as Sir Proby Cautley's quotations from him in other places show that he thought it could not be tolerated that we in Madras should know how to build weirs on sandy rivers with a certain fall, &c., when they had been so frightened at the idea of it that they had not even attempted it. It takes off the edge of our boasting to have to acknowledge that both the idea of Anicuts themselves, and the means of constructing them with perfect ease in sandy beds by means of well foundations, had been learnt by us from the native Engineers. It was not that any genius had arisen among us, who had not among them, though that might have occurred even in Madras; but that we had before our eyes that which had been effected by others before us, which they had not. If any credit was due to us it was only that appertaining to our believing our own eyes, which it is evident Colonel Smith did not do, or he would not have insisted on there being fever in our Deltas, nor upon the destruction of weirs if they were built in the North West; and the same with Sir Proby Cautley—it is evident he finds it difficult to believe his own ears. Perhaps the real difference between us and our Bengal brother officers is that we are willing to learn from others. But it is more probable that if they had there been preceded by as able native Engineers as we have in Madras, they would have learnt the same invaluable lessons as to the right system that we have; and we might now have been found committed to a false system, and earnestly persisting to attempt to defend it, in the face of the most unquestionable and even unquestioned success of the former, and failure of the

other, for it certainly is very hard for men to allow that they have been misled.

So, also, Colonel Baird Smith complains of the bridges not having been built in Rajahmundry. In the first place, why did he not add—"But in Tanjore, where the works are "in a more advanced state, many thousand bridges have "been built, so that every considerable town is directly "connected with every other in the district with completely "bridged roads, and thus in that small district there are "1000 miles of road without a ferry." I am glad, however, that Sir Proby Cautley brings forward this point of the bridges not being built at first on the Godavery, because it gives me an opportunity of pointing out what I consider a fundamental principle in the execution of these works, and which has in general been carefully acted on in Madras—viz., to distinguish between shadow and substance, to keep carefully in view the great objects and distinguish them from minor ones, and so take care that we are not expending our time, money, and energies among comparatively insignificant things, while we let the essential ones slip through our fingers. "Our great objects in the irrigation works were—1st. To prevent famine, &c., in the particular district. 2nd. To obtain such direct results in money as to make those works a source of encouragement to the Government to extend the irrigation generally.

I grant that in doing this we had to sacrifice many minor things for the time; but, universally, this holds good, that we must either sacrifice the major to the minor, or the minor to the major. And certainly, nothing can be more evident than that we have, under God's blessing, in this way fully attained our ends.

Rajahmundry is not only free from famine, but it is in

the highest state of prosperity at this moment, having made such progress as no other district ever did in India.

Secondly. Its state is now, as I have said, our grand argument in favour of the extension of the system of regulating the water of India generally; the clear profits to Government in money are so enormous as to sweep away every sign of ground for the old argument against such works—"We cannot afford it." These works have not only paid their interest, but their whole cost also, at least twice over in Government revenue, so as to prove not only that we can afford to execute them, but that even if only a small portion of India were thus treated, we might abolish some of the worst taxes, and thus not only relieve the people, but incalculably strengthen the Government. When I first was appointed to Rajahmundry, I had to decide before I could take a single step which I was to sacrifice, the general and effective improvement of the district by a complete system of works, or the repairs of the petty works already in existence. I had one inexperienced assistant, and it was impossible for us to do both. We had not even one surveyor whom we could trust with a line of levels, and we had to take them ourselves. I therefore left all the old works to themselves, while I took in hand the projection of the great works, being fully assured that the repair of the old, petty, inefficient works was a matter of utter insignificance in comparison with the general reformation of the district by a system of great works; and this principle of action we endeavoured to keep in view throughout—that is, always to execute the works of essential importance in preference to those of minor significance. The case of the bridges was precisely a case in point. Suppose the bridges would have cost £100,000; the real question was, which

was most required—£100,000 worth of bridges, or £100,000 worth of irrigation and navigation: suppose 200,000 acres of the former, and 200 miles of the latter, there could be no doubt which should be done first. It was certainly some inconvenience to ferry across the canals, but it would have been still more inconvenient to die of famine for want of them. I am sure we have had a striking proof of the results of the opposite principle in the Ganges works; when the famine came, the people had the convenience of bridges to pass the canals, and the inconvenience of dying by tens of thousands for the want of the distributing channels to convey the water to the lands. The water had been led only to a small portion of the lands to be irrigated. Supposing £100,000 to be spent on the bridges, had that sum rather been spent on distributing the water, I suppose 300,000 or 400,000 additional acres would have been watered, and tens of thousands of lives would have been saved. It would have been a far less evil for the people to be ferried across the canals for a few years, till the Engineer was at leisure and had the means to construct bridges; and so also with the navigation. It was of incalculably more importance that the works connected with it should have been in a completely effective state, so that the hundreds of thousands of tons of food required for the perishing multitudes should be conveyed through those tracts, than that the people should have the use of bridges. And thus we have a magnificent canal, with most convenient bridges at every 3 miles, and nothing could look more complete; but in consequence of so much superintendence, money, time, and labour having been expended on bridges, which could have waited without any serious inconvenience, rather than upon the irrigation and navigation, when the famine came

was most required—£100,000 worth of bridges, or £100,000 worth of irrigation and navigation: suppose 200,000 acres of the former, and 200 miles of the latter, there could be no doubt which should be done first. It was certainly some inconvenience to ferry across the canals, but it would have been still more inconvenient to die of famine for want of them. I am sure we have had a striking proof of the results of the opposite principle in the Ganges works; when the famine came, the people had the convenience of bridges to pass the canals, and the inconvenience of dying by tens of thousands for the want of the distributing channels to convey the water to the lands. The water had been led only to a small portion of the lands to be irrigated. Supposing £100,000 to be spent on the bridges, had that sum rather been spent on distributing the water, I suppose 300,000 or 400,000 additional acres would have been watered, and tens of thousands of lives would have been saved. It would have been a far less evil for the people to be ferried across the canals for a few years, till the Engineer was at leisure and had the means to construct bridges; and so also with the navigation. It was of incalculably more importance that the works connected with it should have been in a completely effective state, so that the hundreds of thousands of tons of food required for the perishing multitudes should be conveyed through those tracts, than that the people should have the use of bridges. And thus we have a magnificent canal, with most convenient bridges at every 3 miles, and nothing could look more complete; but in consequence of so much superintendence, money, time, and labour having been expended on bridges, which could have waited without any serious inconvenience, rather than upon the irrigation and navigation, when the famine came

the country was not prepared for it, and the money returns are still so small that this great work,—instead of being as it might and ought to have been, our grand argument in favour of extending the inestimable advantages of regulated waters throughout India,—is at this moment the grand argument in the mouth of our opponents. I am sure nobody can deny that this is the actual state of the case, and the actual result of forgetting the substance while we grasp at the shadow; we have the shadow of a grand and complete *looking* work, and have lost the substance of protection from famine, and of such profits as would justify the Government in prosecuting the enterprize. This alone is one incalculable advantage of having the works in the hands of a private company. Shareholders cannot be deceived in this way; they will certainly know and feel whether the real object has been kept in view—the judicious, and consequently profitable, expenditure of their capital. They have a rather uncourteous proverb in the North—“Fules and bairns shouldn’t see half done turns;” and of course, in following out this essential principle, we incurred the danger of inexperienced visitors to the district while the works were incomplete, thinking “what a mess everything is in;” but this is counterbalanced by the unspeakable comfort of seeing the district prospering, the Government satisfied and encouraged, and the whole scheme of the irrigation and navigation of India immensely forwarded. They have not even yet built the bridges in Rajahmundry, and I am sure both what has occurred there and what has occurred in the North West, is only calculated to prove beyond all question the soundness of our principles, and to make me hope that the people will continue to ferry across the canals of Rajahmundry till the

remaining 300,000 acres have been irrigated. Nobody can doubt that the two or three lacs allowed per annum for these works should also be expended on completing the distribution—that is, in the irrigation and navigation rather than in building bridges. If Colonel Baird Smith had had an estate in those parts of the district to which these things had not extended, he would clearly have understood which was of most consequence. The source of Colonel Smith's false judgment in this case was, that he did not see that the question was not whether bridges should be built or not, but which should be first provided for, the irrigation and navigation, or the passage of the canals by bridges rather than by ferries. And so also with the general effect of the works upon the whole question of regulating the waters of India. If the Ganges Canal had no bridges still, but a million acres were under irrigation, and the navigation were in an effective state, the profits would be now perhaps 10 per cent., and Mr. Laing would be no longer able to say that the Ganges works are not yet profitable, and therefore that the Government cannot afford to prosecute such works, necessary as they are even to prevent famine. It will be seen by the extracts from the Despatch from the Government of India, given towards the end of this paper, that I do not stand alone in these views, but that I am supported by Lord Canning and the whole Council of India at Calcutta at that time. But the Government are not called upon to expend any funds. Private companies will, when once it has appeared that good profits have been realized by one, come forward with money more than sufficient; the country will rapidly become prosperous in all its parts, and an overflowing treasury become the state of things; for, as it was once so well expressed in a Native

petition—"THE GOVERNMENT OF A PROSPEROUS COUNTRY NEVER CAN BE POOR."

In the course of his remarks at page 79 Sir Proby Cautley quotes from Colonel Baird Smith that if weirs were constructed on the Ganges similar to those in South India, "they would inevitably fail on the first serious trial." But this is no new thing. Men entirely without experience in a matter, when they first see certain works are greatly surprised. They always think that most important things have been neglected, and most unnecessary things done. But this is because they are ignorant of the case. Till we have had actual experience, we always make vast preparations against difficulties which do not exist, and entirely neglect the really important points. No doubt Colonel Smith thought that if these works did stand, at all events they ought not. But to say that works which stand in Madras would not stand in the North West in similar soil, but, with one-third the depth of water, and half the height, and a much weaker current, is simply nonsense. We are quite certain that what resists a certain force of water in a sandy river in Madras will stand a quarter or a tenth of the same force in the North West. What possible use can there be of this sort of writing? Who can imagine that the Kistnah Anicut, 16 feet high, built in 35-feet water in a current of $7\frac{1}{2}$ miles, with 20 feet of water passing over it, will stand in a sandy bed; but that if a similar structure were built 8 feet high in 2 feet depth of water with 4 or 5 feet of water to pass over it, if built in the North West, in the same foundation, "it would inevitably fail in the first serious trial." If Colonel Smith had argued in this way, "Well, whatever I may suppose, as I have had no experience in Anicuts, I am of course mistaken; for here I see

“several vast works standing for years in such situations,
 “in a depth and current so far beyond what we have in the
 “Ganges below the hills, and I can only conclude that all
 “our ideas about the insuperable difficulties of such works
 “are imaginary, and simply the consequence of our want of
 “experience;”—if he had argued thus, I think it will be
 allowed that he would have been nearer the mark.

✓ At page 88 Sir Proby gives the following as the widths
 of the rivers according to Colonel Smith:—

Cauvery, 1 mile, or thereabouts.

Kistnah, $1\frac{3}{4}$ to $2\frac{3}{4}$ miles.

Godavery, 2000 yards immediately above, and 6000 at the
 Dam, or $3\frac{1}{2}$ miles.

The actual widths are—

Upper Coleroon (not Cauvery), 5 furlongs.

Kistnah, 5 furlongs at Dam.

Godavery, 3000 yards at the narrowest part, and a little
 above 4 miles at the Dam,

including islands—that is, what are islands when the river
 is low, but the whole submerged several feet when the river
 is in flood.

Sir Proby then speaks of my *determining* the cost of
 the weir on the Ganges. I did not pretend to *deter-*
mine the cost. I had ample means of forming a rough
 estimate of the cost, knowing the nature of the bed, and
 the volume of water we had to deal with, and the actual
 cost of so many similar works; and this was all I pretended
 to do. The cost could only be determined when the actual
 site of the works, &c. was fixed.

At page 90 Sir Proby Cautley speaks of my mentioning
 12 miles as the length of canal to the Futtighur branch,
 and 50 miles to the main branch. The two are not, how-

ever, contradictory. At the end of the 12 miles the water reaches the high land of the Doab, and begins to irrigate the land; at the end of the 50, it reaches the highest ridge, and from that point commands the whole country.

Sir Proby Cautley next quotes some lines from the middle of a long paragraph of Colonel Baird Smith's report on the Madras works, which contain simply a pure invention. Nothing can be more evident than that to accuse an officer of falsehood *without supporting that assertion by any attempt at proof* is wrong, and for another to repeat it is one degree worse. It is, however, of importance that this has been done by Colonel Smith and Sir Proby Cautley, because it shows how perfectly they felt that a case was lost, when they had recourse to such weapons; for certainly nothing but desperation could drive gentlemen to the use of such means; when such men condescend to throw mere dirt, it shows that weightier missiles are not at hand. I may also remark upon Sir Proby's not only quoting this portion, but, moreover, omitting all mention of the rest of the same long paragraph in which Colonel Smith bears the strongest testimony to the efficiency of the works in Tanjore, speaking of "the permanent prosperity of Tanjore, its present large revenue, and the favourable condition of its inhabitants—so remarkable as at once to arrest the attention even of a very indifferent observer—without question to be attributed in large measure to * * * * the construction of the Upper Coleroon Anicut, &c." When men thus so entirely forget themselves as Sir Proby Cautley has here, no observer can need any further proof of an endeavour to uphold the wrong side, for people do not lose their self-control till they feel that they have lost their cause.

Sir Proby Cautley next objects to my rough estimates of additional heads to canals from the Ganges and Tamra

lower down, but as he gives no reason for thinking they are not tolerably correct, I have nothing to answer. He objects also to my quoting the Toombuddra works as a proof that it was no such impracticable work to lead water out of a river upon a plain 70 feet above its bed, through a country perfectly flat, and without a stone in it, when a canal was nearly completed which led the water through an undulating and rocky country to 150 feet above the river. What in the world Sir Proby Cautley can see in this seriously to find fault with, I cannot imagine. Is it very unlawful to take encouragement from what others have accomplished to try and do something of the same sort? He then proceeds to find fault with some of the details of these works. I am not going to fight this battle, though I dare say the works have been very well executed; but his mentioning these details only shows that he cannot answer my argument from the work itself; viz. that we ought to be ashamed of making any fuss about leading water out of the Ganges below the hills on to the Doab, when such incomparably more difficult works have been executed by others. It is, however, necessary that I should observe that Sir Proby Cautley has unfortunately in this part of his "Disquisition" again travelled out of the public path; but in doing so I am afraid he has simply soiled his own hands, and certainly has not strengthened his advocacy of the original projection of the Ganges Canal. In my paper of comments upon his first reply I referred to *certain portions* of the scheme of works under prosecution by the Madras Irrigation Company, specially describing *such portions* as consisting of 72 miles of canal, including an Anicut across the Toombuddra, an Aqueduct over the Hindry, and a rocky cutting; and I expressed my *belief* that those *specified* works, which formed *a small part of the whole scheme*,

would cost about 200,000*l.* or 250,000*l.* Sir Proby Cautley is a Member of the Council of India, and one of its Committee on Public Works in India, and should therefore be at all times thoroughly well informed upon all matters relating to the proceedings of the Company named, the Secretary of State having and exercising a right of control over its affairs, and no step being taken or expenditure incurred by it without the full knowledge and sanction of Government. Having this knowledge, Sir P. Cautley has, I think it will be admitted, with undue haste, and without due regard for his own accuracy, thus remarked upon my statement and belief of cost, after quoting my words which distinctly name, as I have just said, *specific portions* of the scheme:—

“Why should the Madras Irrigation Company be
 “dragged into this discussion, except with a view to glorify
 “an undertaking projected under the auspices of Sir
 “Arthur Cotton? The readers of this pamphlet will
 “necessarily accept a statement of this sort coming from
 “such high authority, and would not suppose that there
 “could be any doubt in its correctness. The facts are
 “these:—

“Up to April, 1863, nearly 36 lacs of rupees, that is to
 “say, £360,000 sterling, had been expended on *the above*
 “*works*, the state of which in the month of August, four
 “months later, was as follows:—”

I have now been furnished by the Madras Irrigation Company with the following statement of their expenditure at the time named by Sir Proby Cautley.

“The total expenditure incurred by the Madras Irriga-
 “tion and Canal Company on the 1st of April, 1863, was
 “£334,554. This included preliminary expenses, cost of
 “management stores, &c., connected with the works.”

“ the main canal of which is over 600 miles in length, and
 “ a large quantity of stores was also then in hand.

“ Of this £334,554, there had on that date been ex-
 “ pended in and on account of the particular works speci-
 “ fied by Sir A. Cotton, including a very liberal proportion
 “ of all general expenditure, £196,000.”

Sir Proby Cautley next sums up his objections to a weir below the hills.

“ 1st. Engineering difficulties of making and maintaining
 “ a dam.

“ Bed confined in a trough, and of a sandy and treacherous
 “ character.”

I have shown that the river being, as he calls it, in a trough (that is, at a considerable depth below the surface of the country), does not at all affect the construction of the dam,—no afflux of consequence being occasioned by an Anicut *during floods*,—but only the length of the canal to lead out the water upon the plain. As for the sandy bed, it is just the same as our Madras rivers.

“ 2nd. Volume of perennial supply in the river.”

We had just as much to dispose of during a great part of the working season in the Godavery, and arranged for it by temporary dams without any excessive expense.

“ 3rd. Limited period during which the river is left un-
 “ touched by floods.”

We had the same difficulties in the Madras rivers.

“ 4th. Absence of stone and lime quarries, and scarcity
 “ of brick earth and other materials.”

These will certainly increase the cost, but I allowed for all in my rough estimate.

“ 5th. Rafts, trees, and rubbish floated down during the
 “ floods.”

We have just the same in the Madras rivers.

The actual cost of the Godavery and Kistnah Anicuts has been about 4000 rupees per million cubic yards of water discharged per hour; taking the Ganges at 25 millions, this would give only £10,000. I have therefore probably allowed amply for the cost of the Anicut, for the above includes the expense of overcoming all the difficulties above enumerated. Sir Proby Cautley further objects—

“1st. A great portion of the low land, &c., is rich in villages, &c., a rise in the surface of the Ganges 20 feet, or even 15 feet, &c.” But as I never intended to raise the level of the Ganges 20, or even 15 feet—nay, not even 1 foot—or to flood a single square mile, I should not have this difficulty to contend with. No lands are flooded by the Anicuts in Madras. All these objections only show more certainly that Sir Proby is imperfectly acquainted with our system.

“2nd. Effects upon villages and valuable lands by inundation.”

“3rd. Evils in a sanitary point of view.”

I have not the least intention of leaving anything undone that may be necessary in a sanitary point of view. Now, really, for Sir Proby gravely to say it requires new blood to propose and seriously recommend the establishment of such evils, is strangely absurd. Where have I said one word that implied I intended to produce inundation or neglect sanitary arrangements? One of my grand arguments for irrigation works is, that in thus regulating the water we take the most effectual means for promoting the health of the population. Every acre is drained and protected from floods, and a stream is brought through every village, so

that both all stagnant waters are carried off, and no portion left for the people to drink, and every one is supplied throughout the year with running water direct from the river. When Sir Proby accuses me of inundating the country and creating fever, he accuses me of producing the very results which the Madras system of works prevents.

Sir Proby Cautley concludes by finding fault with the omission of the foot-notes in his memorandum, referring to the pages of mine on which he is remarking. I had nothing to do with the printing, and never observed that the foot-notes had been omitted, and probably if I had superintended the printing I should have omitted them, not imagining them to be of the slightest consequence. Their omission, however, was quite unintentional on my part.

I must again express my extreme regret that this discussion should have caused Sir Proby so much annoyance. If it were merely a personal question between himself and me I should have made no reply to his "Disquisition," but it really is a matter of the greatest public importance, and I could not possibly let the matter rest. Sir Proby Cautley does not understand the Madras works, and his remarks are calculated to leave very mistaken impressions on the great subject of irrigation and navigation with which the well-being of India is so inseparably connected. People generally, who only know that Sir Proby Cautley is, or was, the Engineer of the Ganges Canal, are not aware that he is entirely without any experience in the Madras system, and will ascribe an authority to what he says about it which cannot possibly be due to one who has never seen the works, much less actually encountered and overcome the difficulties that do exist in carrying them out, as well as of getting out of his head those that have no existence

in the operations themselves, such as that the country will be deluged by a weir that does not raise the level of the floods, that works which drain every acre and supply every one with flowing water for drinking, &c., will lay waste the country with fever, that *running* water is required for navigation, &c. &c. His awful account of inundations, villages destroyed, fever, &c., as the consequence of an Anicut, is only one of many things which show that he greatly misapprehends the subject, and is a partaker in the *fancy* common to non-professional men, that if we raise the dry season level of the river by an Anicut, we must needs raise the flood level several feet. But surely we may fairly urge that if these or any other desperate evils were the consequence of those works, they would have been heard of before now. It is most evident from the tone of Colonel Baird Smith's Report on the Madras works, and his public assertion of an abominable and unfounded personal charge against me, entirely his own invention, (for I am quite certain he never saw or heard it made by anybody else,) that he was under almost as strong a bias as Sir Proby Cautley himself, and that if he could have made out that the works in Madras flooded the country, swept away villages, and depopulated cantonments and towns by fever, he would certainly not have omitted such things. But he only says what implies that there ought to be such calamities, he does not mention any having actually occurred. For my part, as long as they do not actually happen, I do not care whether they ought or not; and while our Madras works have produced nothing but rice, sugar, &c., and their consequences, freedom from famine, the wealth and satisfaction of the people, overflowing treasuries, as well as cheap transit and enormous traffic internal and external, I

am very well content, and only wish to see so completely successful a system extended to the North West and every other part of India. I am sure I have the best possible right to an opinion on this point after the experience I have had with so many different rivers, and I am as certain as I am of anything in the world that this system is perfectly applicable to the North West, and that if it had been adopted there originally, there would have been many years ago just as great results there, both as respects direct profits to Government, the prevention of famine, and the increased wealth and satisfaction of the people, as there have been in Tanjore, on the Godavery, and on the Kistnah, the same increase of revenue, the same increase of traffic, the same extension of foreign trade, the same cheapness of passenger traffic, &c. ; for certainly the Gangetic tract has far greater facilities for irrigation and navigation works than the Godavery and Kistnah Deltas have. Observe only the difference in the rivers we have had to master, their magnitude and great depth compared with the Ganges where it leaves the hills. We have certainly less difficulty in leading out the water upon the land, but not much. One of the main channels of the Godavery does not begin to water till it has reached about the twelfth mile, or just about the same distance as we could begin to water at in leading water from the Ganges. I can with the utmost confidence assert that if the Madras system had been adopted in the North West there would have been 1 or 1½ million acres under irrigation before the famine, there would have been the most effective system of navigation in the world, so that any amount of food might have been brought by the river to Allahabad, and have been conveyed by the canals to many parts of the suffering tract at a

trifling cost, and some 10 years ago there would have been direct returns to the Treasury of at least 25 per cent. Those works would have been in full operation before one-half of the actual expenditure had been laid out, and I feel confident, however these discussions may appear to those who are committed to the North West system—and at this moment they abound in high official quarters—those who are not, and can afford time carefully to consider the papers on both sides, whether professional or non-professional persons, will be satisfied that I have very good ground for my confidence, and consequently, that though unhappily so much time and money have been irrecoverably lost, yet that it is of the utmost importance that the subject should be thoroughly considered, and, if possible, impartially examined, that we may see if by the introduction of this system the project may not yet be rescued from its present *acknowledged* unsatisfactory state—unsatisfactory not only in respect of money returns to Government, but of the security of the works, and even their effectiveness in respect of supply of water and of navigation.

There is something unaccountably curious in the fuss that has been made about this simple and petty work—the Ganges Weir. If one of our Madras officers, who had only a few years' experience in such works, had been sent there, it would not have been a moment's question with him whether he ought to have entangled himself with the Sewalik streams, or to have begun clear of all difficulties below the confluence of the Solani. ✓ He would have seen at the first glance that there was not a shadow of a difficulty about a weir in such a situation; nor would he have thought for a moment of fetching water for the irrigation of the land round Cawnpore from a height of 600 feet above it, and a

distance of 350 miles, when he could have got it within 50 miles. After seeing a river of 200 million cubic yards per hour, and 30 feet deep controlled without any extraordinary difficulty, excepting that arising from the great extent of the work, and costing only 85,000*l.*; how could he have hesitated or imagined any difficulty with one of perhaps 30 million cubic yards and 14 feet deep, and how could he have thought of going 300 miles farther up the river for water. A weir to discharge 30 million cubic yards even if it cost four times as much in proportion as the Godavery Weir, would only require 50,000*l.*; and a canal of 50 miles, to carry suppose a million cubic yards per hour, would not cost above 1000*l.* a mile, including masonry works, or 50,000*l.* more, and this 100,000*l.* would have provided for the irrigation of half a million acres, or at the rate of 2 rupees an acre for the cost of the head-works, to which would have to be added the cost of distribution, navigation, &c. In this way the water for the land near Caynpore might have been brought from the Ganges at a point only 50 miles distant from it.

In thus discussing a great public question it cannot be but that personal feelings may be greatly disturbed, but I must insist upon the absolute necessity of bringing forward as clearly and forcibly as I possibly can, what I consider the true state of the case, though in so doing I must necessarily write many things which, if it were only a personal question, might be left unsaid, and therefore ought to be. For anything that I have said that seems needlessly annoying, I do most earnestly apologize; but what public duty really requires needs no apology.

Originating with native Engineers, we have carried out a

body in that Presidency, black and white, civilian and Engineer, and even the India Office authorities themselves — though the bias there, so far as it goes, excepting on the part of one or two individuals, is entirely against the Madras Engineers, the professional members of the Council being Bengal officers — has been eminently successful. There is not the shadow of a question about this. It has pleased God so to prosper our works there, that this point is decided. The increase of revenue in the one district of Godavery alone, is about $\frac{1}{4}$ million; and there is every reason to believe that it will nearly or quite double that, when the works are completed, and the water-rate levied on the whole of the lands. If only the additional revenue already realized there were extended by the same means to 20 districts out of 130, both the Income and the Salt Taxes might be abolished, and a feeling in favour of our Government thereby created, both in the upper classes and in the great mass of the people, the effect of which in every salutary way it is really impossible to estimate. I cannot express the satisfaction I have in this discussion, having the fullest confidence that though perhaps not immediately, because it necessarily produces at present considerable irritation, yet before very long it will greatly forward the cause of irrigation and navigation in India. There is a saying, “save me from my friends;” and so, on the other hand, we may just as truly say, “commend me to my enemies;” or, as it is so exquisitely expressed, “Oh, that my enemy had written a book!” No friends could possibly have done for me what my present opponent has done. He has not only given me an opportunity of answering the things which are hanging about the minds of many who have no practical acquaintance with the subject of weirs, irrigation, and

navigation, but has given me access to numbers who would have cared nothing otherwise about such a matter, and so brought about legitimate discussion, from which great good must result.

We may fairly expect that before very long we shall have a financier for India capable of understanding this simple proposition, that what has added a quarter of a million to the revenue of one district, not only without producing irritation amongst the people, but just the opposite, intense satisfaction, is worthy of consideration, and affords a prospect to the manager of those matters that no cunningly-devised tax could possibly do. May we not fairly hope that before long some wonderful genius will appear on the scene who will be able to comprehend even this, that the old clumsy plan of new taxes ought to give place to this incomparably superior operation of first giving the people one or two millions increase of income, and then out of that receiving a quarter of a million, especially when it produces a multitude of other benefits, without one drawback? But even in the present state of things, with the power of the great body of official people against it, the whole scheme of regulating the waters of India is making good progress. The works now actually in hand are calculated to irrigate nearly 10 millions of acres, and to provide with navigation about 50,000 square miles, and a population of perhaps 20 millions, so that some real impression is being made. All this has taken place without one statesman or financier having yet appeared who was able so to comprehend the bearing of this question on the well-being of India, as to heartily adopt the undertaking, and take it up as a great and fundamental object. It has made its way bit by bit, as it was forced upon the authorities by this or that

subordinate officer, or by the two struggling Irrigation Companies. But should some one come forward in a commanding position, who is capable of comprehending the subject, and who should take the trouble to master it, and boldly take up the scheme of the regulation of the waters of India as a whole, especially by English companies, he will most assuredly acquire such a name as no other ruler or financier in India has ever acquired, if God is pleased to forward his labours. A fact it is, whether men choose to ignore it or not, that the Madras system has produced effects upon the prosperity of all the districts where it has been tried far beyond what anything else has done, and the system is most assuredly capable of universal application in India. Nothing but mischief can result from the refusal to acknowledge this fact, that of all the districts of India, Tanjore, Godavery, and Kistnah alone have made this astounding progress in revenue, without the oppression of the people, but, on the contrary, a vast increase of the wealth of the whole population—and no ingenuity can get rid of this fact. The only wisdom is heartily to acknowledge it, examine it thoroughly, ascertain the causes, and then without bias consider to what other parts of India the system is applicable. I insist that it is no boasting, but the palpable truth, that nobody has had so long experience in these works as I have, and therefore that no one has a better right to an opinion on this point; and my opinion is, that the whole plain of the Ganges has greater advantages for such works than any of the districts in which the system has already been tried; that the natural difficulties are less than those in Madras; while there is no comparison between the two as to the extent of *traffic* which would be produced. There can be no comparison in this respect between isolated

patches, as the improved Madras districts are, and a system of cheap transit extending over a length of 1000 miles, and uniting a population of, some 50 millions with each other, and with foreign ports. I must again express my assurance that this discussion will have immense effects, that while a few are too far committed to the system that has failed to produce direct returns, to cease to try and prevent the real state of the case from appearing, a far greater number, less under the influence of bias, will be to a great extent convinced by it of the soundness of a system which has been entirely successful, and that thus there will be a palpable weakening of the opposition that has hitherto existed against the agency that has been raised up, and which has proved itself capable of comprehending and carrying out these noble works on a scale worthy of them and of England.

• The late Lord Canning, towards the close of his administration, began to view this, to India, all-important matter in a true statesmanlike and impartial manner; and so also did several members of his Council, and these were well supported by Colonel Yule, who then most ably performed the duties of Chief Secretary to the Government of India in the D. P. W.; and it is with great pleasure that I transcribe—in support of this statement, and for the purpose of showing that the true nature of the Madras system of irrigation works was then candidly acknowledged at Calcutta—the following paragraphs from a despatch of the Government of India immediately before the departure of his lordship for England, relating to a proposed scheme of Irrigation Works in Behar, which that Government were anxious should be taken up by the East India Irrigation and Canal Company:—

“ We have long regarded this great scheme as one of
 “ all others in India to which private capital should be
 “ invited.

“ There is this advantage in Government taking the in-
 “ itiative in planning the great works of the country, that
 “ they are so placed before the public that they can be
 “ discussed in the light of local knowledge and experience.
 “ The only drawback to doing this is the risk of misleading
 “ capitalists and raising mistrusts of such investments.

“ In the present instance no such risk need be appre-
 “ hended, for there is evident throughout Colonel Dickens’s
 “ Report a most conscientious endeavour to anticipate the
 “ maximum cost of the work.

* * * * *

“ We have frequently pressed upon Her Majesty’s Go-
 “ vernment our views regarding the distribution of profits
 “ derived from irrigation works constructed by joint-stock
 “ companies. This subject was a prominent one in our
 “ late correspondence regarding the East India Irrigation
 “ Company, and we then repeated our conviction that the
 “ determination of a liberal maximum of profit beyond
 “ which a division should take place, is the right principle
 “ to work on—a principle whereby the proprietary right
 “ of Government in the public waters of rivers is recog-
 “ nised, and its equitable rent of those waters secured.

“ To apply the above principle to the particular case
 “ under consideration, we observe that the estimated re-
 “ turns of the work amount to $8\frac{3}{4}$ per cent. on the outlay.
 “ This at least is the return ultimately looked for by
 “ Colonel Dickens, but it will be of slow growth if the
 “ work should be at once carried out on the permanent
 “ design. But our belief is that the first cost of the work
 “ might be considerably *reduced by working more on the*
 “ *Madras system of dispensing with permanent bridges, and*
 “ *other costly works at first*; and we may remark, that
 “ the first step of the person appointed to undertake the
 “ work should be the study of the Kistnah and Godavery

“ *Works on the spot.* There is no doubt that a revenue
 “ has been initiated by these works with much smaller
 “ means than in the irrigation works of the North-Western
 “ Provinces, where no revenue has been realized until the
 “ expenditure had gone on for years, and the heaviest ma-
 “ sonry works had been completed. Colonel Dickens does
 “ propose this in his scheme of gradual execution ; but we
 “ are inclined to believe that it could be carried much
 “ farther, and on this *we shall obtain the views of officers of*
 “ *experience in the Madras Delta Works, whose opinion will*
 “ be valuable.

“ (Signed)

CANNING.

R. NAPIER.

H. B. E. FRERE.

S. LAING.

C. BEADON.

W. NAPIER.”

This was, indeed, a step in the right direction, and one which all who desire to make India prosperous must fervently desire to see promptly and liberally developed.

As matters now stand, my main propositions for the rescue of this important work—the Ganges Canal—are—1st. To construct a weir with a new head for the canal somewhere below the confluence of the Solani. 2nd. To admit only 3 or 4 feet of water by the present head, so as to keep the current, down to 3000 yards, such as the bed and works can bear. 3rd. To diminish the fall in the lower part of the canal by additional weirs, and thus to allow of the canal being filled to a greater depth. 4th. To build new stone weirs out of the line of the canal, of a moderate length, instead of the present ones. 5th. To correct the defects of the navigation by an additional arch to every bridge, and by additional locks where necessary, &c., as detailed in my former papers. 6th. To construct an additional weir on each of the rivers, 200 or 300 miles below the present head, so as to throw a

extend the canal to Allahabad, and by aqueducts to connect it with the proposed canals both in Oudh and South of the Ganges. These are the main points I recommend. I have not the least doubt that if these works are carried out by experienced officers—and by this I mean officers who have had actual experience in weirs, &c.—that the whole project may be put in a thoroughly effective state in every respect, in respect of security, of profits, of navigation, of forming part of a general scheme, &c.; and that thus an immense and permanent benefit will accrue to the country.

Having thus, as I insist, replied to every part of Sir Proby Cautley's Disquisition that really bears upon the question, I have only to call the attention of my readers to the fact that, while Sir Proby has endeavoured to meet the arguments I have used in a few points, he has not even attempted to answer five-sixths of what I have written, which is of course an acknowledgment that he could not do so; for it is impossible to avoid the conclusion from the tenor of his paper that if he could have found any other points which appeared to him to offer the smallest hopes of a successful attack, he would not have failed to try his strength upon them.

Having thus said all that I believe to be necessary by way of reply to Sir Proby Cautley, I feel it to be an important duty incumbent upon me to add a few words of warning with reference to the present and future treatment of the Ganges Canal. I have reason to believe that it is still determined to try and patch up this important work upon the system which has been already so thoroughly tried, and has so seriously failed, without calling for the opinion of Engineers who have had experience in the successful

Madras system of weirs, &c. It seems that the sound sense expressed by Lord Canning, his Council, and his Engineer-Secretary, in the despatch I have before quoted, has again been renounced; and the Government of India have fallen back once more upon the old Bengal views. This is a terrible disappointment to those who hailed the despatch as the commencement of a really wise policy. I fear much that we must now look for and expect the loss of two or three more years, of some hundreds of thousands of pounds, of perhaps some more hundreds of thousands of lives by famine, and of an enormous amount of *prestige*, before those to whom the public works in India are now intrusted will consent to undergo what they must ultimately be brought to—an acknowledgment that the system so long and expensively adhered to, has really failed, and that the Madras system has been signally successful, is capable of universal application, and must be adopted throughout India, and especially upon the Ganges Canal. As the officer who from having had the longest experience in the Madras system, has the best right, and indeed, is in duty bound to do so, I now protest against such obstinate persistence in waste of time and money, such trifling with the lives of the people and the general well-being of India.

Should another famine occur, and it is quite probable, before the only really effectual means are adopted for the effective completion of the irrigation and navigation of this tract, what will be the feelings of those who have thus refused even to call for the opinions of Madras officers, according to the determination expressed by Lord Canning's Government—"We shall obtain the views of officers of experience in the Madras Delta Works?" If, as I think it seems probable, an attempt is to be made to build a weir at

Hurdwar, I urge that I have given abundant reasons in these papers to show that Hurdwar is not the proper site for such a work, but that an Anicut ought certainly to be built below the Solani, though how many miles below I cannot give an opinion, as it would require detailed examination to enable me to do so. But I must also express my doubt as to there being any officer at present employed upon the Ganges Canal who is sufficiently qualified to be entrusted with the building of a weir at all. Such a work can no more be done by instinct than can the cutting off of a limb, and to employ officers on it who are entirely without experience in such works, when those who have it are available, it is quite certain is nothing less than a dereliction of duty. It is evident from Sir Proby Cautley's "Disquisition" that *he* does not understand the subject of weirs, that *he* has not even theoretically made himself acquainted with the subject, and I can positively affirm the same of the officers whom I met on the Ganges Canal; and if they had the theory it would not be sufficient, as everybody knows, without practical experience. If such a work is attempted by men who, though wanting, have not sought instruction, I am certain that there will be a great waste of money at all events, and I should rather expect that there will be some great failures, and then we know what the consequence will be; many will say, "We always said that a weir was not such an easy thing in this locality." I am far from saying that it is an easy thing to those who do not know how to do it; nothing is easy to those who have not learnt, and will not condescend to be taught. When I say that there is no particular difficulty in the matter, I mean, of course, to those who know how to do it. In the per-

emphatically protest against all further trifling with this most important, but hitherto unfortunate work, against all attempts to patch it up on principles which have so signally failed, and I u that all local bias should be at once discarded, and the views held forth in Lord Canning's despatch be reverted to, that experienced men be called in, the whole question fairly and openly discussed, and measures be taken to secure the provision of ample funds, and everything that is requisite to carry out the project to effective completion; and I assert that upon this depends at this moment, more than upon anything else, the well-being of India, because upon the effective management of these works depends the prosecution or stoppage of the irrigation and navigation, the regulation of the waters of India. The entire responsibility now rests upon the Government of that country—they cannot avoid it. They have now the opportunity and the power to secure from imminent peril, and render it a permanently reproductive and immensely beneficial work, an undertaking of great promise, by the adoption of proper and available means, and they possess the knowledge that if they do not exercise this power, the result will be further useless expenditure, postponing only for a short time the total destruction of the finest and most extensive lines of irrigation and navigation yet constructed.

THE END.





A REPLY TO STATEMENTS,

ETC. ETC.

I HAVE before me a pamphlet *On Irrigation and Navigation in Connection with the Finances of India*, and also a *Report on the Ganges Canal*, both of them written by Major-General Sir Arthur Cotton, late Chief Engineer of Madras.

The former consists of an address to the Calcutta Chamber of Commerce, May 7, 1863.

The latter is in manuscript, very kindly lent to me by Mr. J. Westwood, the secretary of the East India Irrigation Company, with permission to print it as an appendix to this paper. It would appear that General Cotton was deputed by the Company to visit the district of Behar, and to plan a scheme of works to be executed there. Whilst on this duty, he appears to have proceeded to the Ganges Canal and its works, and subsequently to have drawn up the above Report, showing value in cash, expenditure required to place it in perfect order, &c., with a view of enabling the Company to make an offer to purchase. A communication to that effect was, as I understand, made to the Supreme Government of India in a letter dated July 27, 1863. A copy of Sir A. Cotton's report was sent on the same date, with

a letter accompanying it, from Mr. Westwood to Sir Charles Trevelyan, Financial Member of the Council of the Governor-General.

To obtain a perfect understanding of the pamphlet so far as it concerns the Ganges Canal works, it is necessary to read the report. The pamphlet itself contains a very imperfect notion of the comprehensive views and strictures of the Major-General, and leaves after perusal a more favourable impression than is conveyed in his report to the East India Irrigation Company.

Before touching on the subject of either the pamphlet or the report, I must be allowed to observe—

1. From the date of the Ganges Canal works being actively commenced by order of Lord Hardinge in 1847, to the period of my leaving India in 1854, the director of the works had an unlimited expenditure of money; no check was placed upon this even during the second Sikh war. Since 1854, with the exception of that period occupied by the mutiny and its effects, Government has been fully alive to the prosecution of the works and the completion of the rajbuhars;—it has shown no remissness on these points.

2. The depth to which the excavation of the canal channel has been carried is stated to have been forced upon me by the proceedings of the Medical Committee! No doubt that the committee did, and very wisely too, urge the necessity on sanitary grounds of such an arrangement, but I should have done the same, in all probability, had the Medical Committee never existed, and for this my reasons will be given hereafter; but as I protest, in the first case, against the Government being accused of being the cause of delays which occurred under my management of the works, so in this, the second case, I decline being relieved from General Cotton's disapprobation at the expense of the Medical Committee.

3. I take upon myself the whole and undivided responsibility of the projection of the works on the Ganges Canal. Blame for their defects rests with me alone.

4. My project was especially for irrigation, as the calculations for discharge and capacity of channel very distinctly show; navigation was entirely subordinate. It was an artificial river, in contradistinction to a series of still-water reservoirs. Nevertheless, strictures are passed on the project as if it had been mainly designed for the purposes of navigation; at least, so the majority of readers of the report would imagine, and so, I must confess, I do.

5. General Sir Arthur Cotton remarks very justly in his pamphlet that, after thirty-five years of active employment on irrigation works at Madras, it is not presumptuous in him to give decided opinions on matters connected with irrigation. I hope that twenty-nine years of my life passed in active employment on works of irrigation in the North-West Provinces of India may be considered by him as giving me and my opinions some claim for consideration.

With these preliminary observations I now propose to take up *seriatim* the censures conveyed in Sir Arthur Cotton's *Report*, and reply to the charges of having been guilty of the "greatest fundamental mistakes in the projection of the Ganges Canal."

These are stated to be in number five, the first being announced in the following words:—

"1. The head of the canal is placed too high up, above a tract which has a very great and inconvenient fall, and in which there is a very heavy drainage from the sub-Himalayas, across which the canal has to be carried."

first twenty miles of the course of the canal from Hurdwar to Roorkee could not have been more expensive than the construction of a weir across the Ganges below the confluence of the Solani.¹ He then goes on to state that a canal officer had informed him that he had taken two levels from the Futtigurh branch to the bed of the Ganges, and found it forty feet on each, while the fall of country is three feet per mile;² hence he argues that, by establishing a weir over the Ganges, and by raising its water ten feet, a canal with a slope of six inches per mile would, in the distance of twelve miles, lead the water out on the present level of the canal.³ The only objection to such an arrangement being the want of stone, and the loss to irrigation of “that particular little patch of country about Roorkee.”⁴

Sir A. Cotton states that, by adopting his plan of annicut over the Ganges below the confluence of the Solani, seventy lakhs would have been saved, besides all the loss and annoyance from the maintenance of so many heavy works.⁵

The above is as sweeping a censure as could have been well devised; and when one looks at a map, what appears more easy than to take a short cut from the Ganges below the Solani junction, and to maintain a head-water by damming the Ganges?

Sir A. Cotton remarks, with apparent astonishment, that this has not even been discussed in the reports he has seen;⁶ and he will be still more astonished when he learns that all discussions which have taken place on the subject, and all experiments that have been brought to bear upon it, have resulted in the inevitable conclusion that interference with the river in this part of its course

¹ App. p. 49.

² *Ibid.*

³ *Ibid.*

⁴ P. 50.

⁵ P. 51.

⁶ P. 49.

would end in utter failure, and that the works would be breached and washed away on the occurrence of the first flood.

An allusion is made by Sir A. Cotton to Colonel Baird Smith.¹ The late Colonel Baird Smith, whose acquaintance with the Madras canals is amply displayed in his report, published in 1856, by order of the Governor-General, under the title of *The Cauveri, Kistna, and Godaveri*, and who was so closely connected with me in the Canal Department of the North-West, and latterly on the Ganges Canal, to the charge of which he was appointed on my leaving India, in 1854, fully appreciated the difference that existed between the engineering difficulties of the Madras deltas and those of the high lands of the North-West Provinces, and was quite satisfied that the projection of the lines of the latter from the shingle, and not from the sandy tracts, was the only true and feasible one.

There is no originality in Sir A. Cotton's proposal; it is an old and exceedingly natural one: our experience, however, in connection with rivers of the nature of the Ganges and Jumna has shown that it won't answer. It has been tried in the Jumna, for the Western Jumna Canals; on the last occasion in 1827-28.

In referring to the report on these canals, printed in 1849, I find the following:—

“An attempt was indeed made by Colonel Colvin, in
 “1827-28, to establish the canal head on the Jumna,
 “at Kulsowra, about forty miles below Dadoopoor. The
 “levels would have answered well enough, but the result
 “of the experiment, which was abandoned after the first
 “year's operations, was merely to show the difficulty of
 “establishing such a work on the Jumna, or in a similar
 “stream, after it has left the gravel and entered the

“ wide and shifting sandy bed, so characteristic of the
“ Himalayan rivers.”

There is a vast difference between the nature of the great Madras rivers on their approach to within sixty miles of the ocean, with all their deltaic attributes, and the Ganges and Jumna on their debouche from the Himalayas, which, at a distance of 1,000 miles from the sea, run in valleys considerably depressed below the surface of the country, on a rapid slope, and over beds of sand of a shifting and treacherous character.

I will, however, endeavour to show by levels, as far as I can at this distance from all papers of reference, excepting the Report on the Ganges Canal, how Sir A. Cotton's line would be brought to bear on the high lands of the Doab (very inappropriately termed by him “ Delta ”). It is necessary that I should fix a starting-point from the Ganges below the confluence of the Solani, so I take the river at Sookurtal, just below Bhokurheri. In referring to the Ganges Canal Report, vol. i. p. 19, and to the Atlas, map 63, it will be seen that a trial section from a point on the old Ganges, twenty-three miles below Hurdwar, at the village of Badshahpoor, gave the following results:—

High land near Kumbhera	88 feet	} Above level of high-water mark at Badshahpoor.
„ Bailra	. . . . .	68 „
„ Futtigurh branch head, Jaoli	. . . . .	52 „
High land near Chitowra	. . . . .	42 „

Sookurtal is ten miles lower down the stream of the Ganges than Badshahpoor. Giving the lowest estimate for the slope on this distance as $1\frac{1}{4}$ per mile, we have $12\frac{1}{2}$ feet to add to each of the above numbers, as marking the elevation of the high land above the river at Sookurtal.

Jaoli, or a point near the Futtigurh branch head, is (see Atlas, pl. 4) 115 feet below zero, or the flooring

of the regular bridge at Myapoor. $115 + 64\frac{1}{2} = 179\frac{1}{2}$ feet, which represents the depression of the bed of the Ganges at Sookurtal.

To descend to the level of $179\frac{1}{2}$ feet, the above plate in the Atlas shows that we must go as far south on the canal as Bhola, or to a point forty-five miles from the Ganges at Sookurtal. As Sir A. Cotton fixes his slope of channel at three inches per mile, this will require a further depression of $11\frac{1}{4}$ feet, so that the channel would not begin to operate as a line for irrigation until it reached Newarri, a town at the ninety-fourth mile of the course of the canal in the neighbourhood of Moradnuggur.

On Sir A. Cotton's plan of adapting the bed of the canal at its departure from the dam or annicut to the same level as its sill or wasteboard, the above distances would be modified according to the height of annicut, whether ten or fifteen feet—if the former, to the eighty-sixth; if the latter, to the eighty-fourth mile.

It would not, therefore, be the patch about Roorkee to which the strictures refer, but the whole of the Suharunpoor, Muzuffurnuggur, and the greater portion of the Meerut districts, that would by this plan be deprived of the benefit of irrigation. So long as irrigation is given to a certain surface of country, it matters, perhaps, little to what country that irrigation is given;¹ but as my intention was, and my project was directed to, the irrigation of the above three districts, it appears rather hard that I should be found fault with for endeavouring to effect it.

To conclude my remarks on this first of the fundamental mistakes, I can assure Sir A. Cotton that the river between the Gurmuhthesur Ghat, 95 miles below

¹ Pp. 49-50.

Hurdwar, up to the confluence of the Solani, has had its due share of attention from me ; and it is from having given the subject so much attention that my conclusions have been arrived at.

Fundamental mistake No. 2 is thus written :—

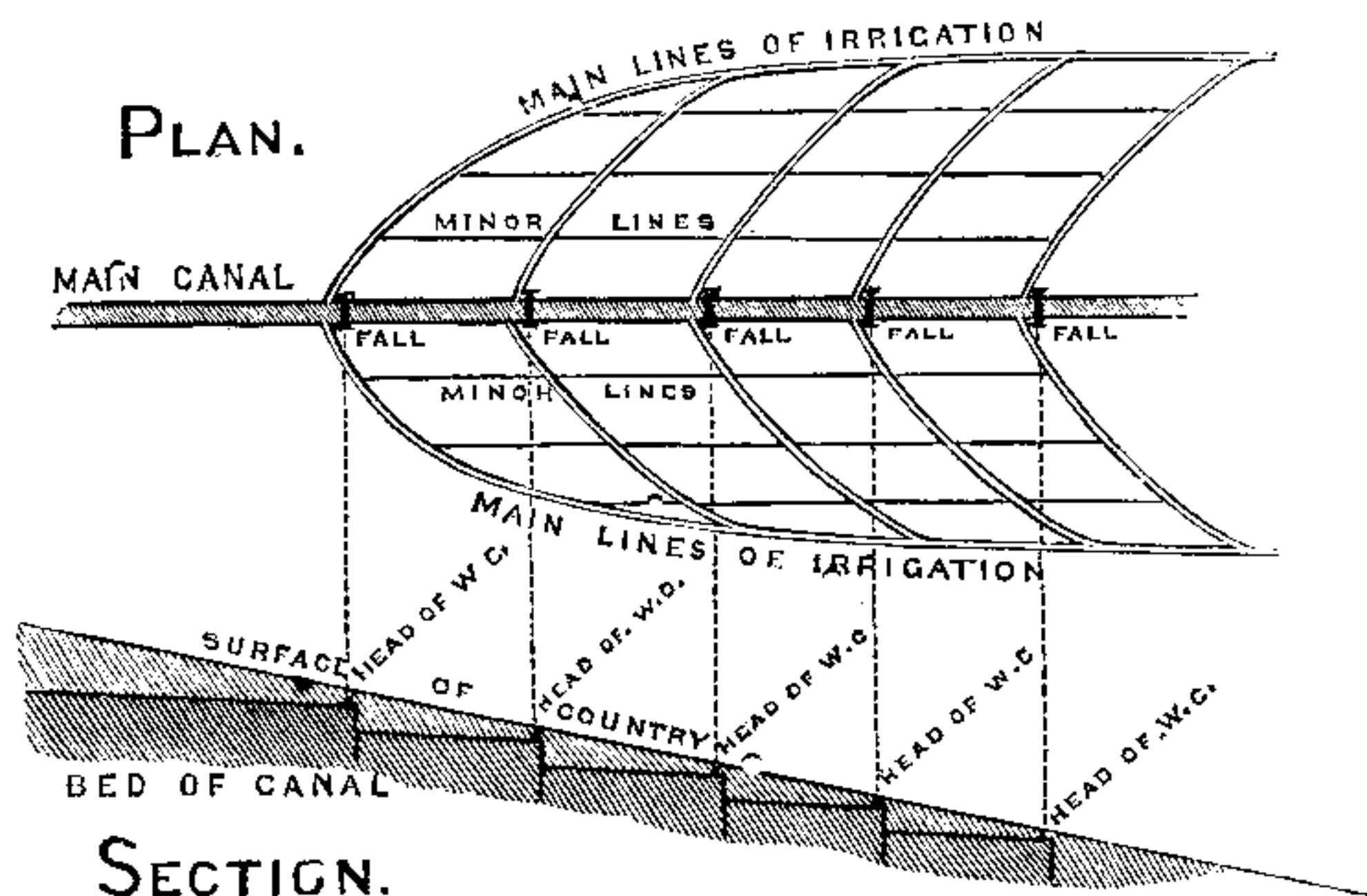
“ 2. The whole canal has been cut so as to carry the
“ water below the level of the surface, entailing a vast
“ unnecessary excavation, and keeping the water below
“ the level at which it is required for irrigation.”

That is to say, the writer imagines that, under my projection of the work, watercourses were to be taken off indiscriminately from the main line of the canal, for the purpose of irrigating the lands *immediately in its vicinity* ! and that, consequently, by deep digging no water for irrigation could be procured without machinery.

My reply to this is as follows :—The slope of the country being much in excess of that of the canal bed, the latter, at certain points, approaches the surface : it is from these points that the rajbuhas, or main water-course heads, are taken off. From these points, the water consequent on the great slope of country is freely delivered over the surface ; and as the lines of rajbuhas are continued in one connected chain from the upper to the lower region of the canal, the water, so far from being kept “ below the level at which it is required for
“ irrigation,” is delivered, or ought to be delivered, on the surface everywhere.

Experience has shown that in the North-West Provinces we cannot, with regard to sanitary discipline, maintain a high-water mark above the level of the country in the main channel. Water standing on raised banks leads to percolation and leakage, with the more ruinous contingency of breaches, from the excavations of otters, rats, and vermin of this description. We, therefore, do not project our main channels on Sir A. Cotton's

design, but we gain equal benefits to irrigation by a judicious disposition of our watercourse heads. The following diagram will explain the arrangement.



The medical officer (to whom Sir A. Cotton refers at page 45 of his Report) is quite innocent of interference in the matter.

I must observe, however, that although on Sir A. Cotton's project and plan of canal making there may have been "vast unnecessary excavations," on mine the excavations made have been quite necessary. In fact, in a protective point of view, the maintenance of the water in the canal channel as much as possible within soil, gives a very effective power of control over the supply.

Had the canal channel been excavated under Sir A. Cotton's orders, the evils of leakage or permeation would not have been prevented.

Generally speaking, the supersoil was good, but by no means of a nature impervious to water; occasionally it was of a very inferior description. Whether good or

depth. The good soil never extended beyond a depth of 8 or 10 feet, and was frequently very much less. In my original surveys, miles in extent of waste land were crossed rich in *Asclepias gigantea* (Mudar), the well-known attendant upon a sandy soil. The sand-hills and collections of drift, which are so characteristic of the Muzuffurnuggur and Meerut districts on those portions through which the canal takes its course, and which also abound on the high land and bank of the Ganges, from Sookurtal downwards, are all features connected with these deposits of sand. Not even the most moderate excavations, therefore, could have prevented the canal water from coming in contact with the sandy substratum; and as it is on this *contact* that the leakage, to which Sir A. Cotton draws attention,¹ depends, the evil—no doubt, a great one—could not have been avoided.

Fundamental mistake No. 3 stands as follows:—

“ 3. The whole of the masonry are works of brick, while the most suitable stone for hydraulic works is procurable in the Sub-Himalayas: this is a most inexplicable mistake.” In another part of the paper, Sir A. Cotton writes: “the excellent stone of Hurdwar;”² and in commencing his strictures, observes—“There is nothing more inexplicable than this in the whole matter. I cannot find a word of discussion on this point in the published reports on the project.”³

The strictures convey a sweeping condemnation on brick masonry to which I by no means agree; nevertheless, where good stone is to be procured at a reasonable price, no man in his senses would select brick. The Sewalik sandstone, however, is of very uncertain quality, and is attended by beds of conglomerate of a similar character. It varies from extreme friability to a crystal-

line rock; in all the gradations through which it passes it is to be worked without any great difficulty. The unequal quality of the stone, however, and the preponderance of that of a very inferior order, renders it a somewhat dangerous material to be introduced on public works. The town of Hurdwar and Kunkhul, the ruins of Badshahmuhal on the Jumna, those on the left of the Ganges, and numerous tombs and mosques in the vicinity of the hills, are built with this stone. The stone that is used is procured at considerable expense and with great difficulty; hard portions are selected at distant and detached points out of masses of the softer rock, and brought to Hurdwar and Kunkhul for the use of the stonecutters. As a rule, however, the Sewalik sandstone is notoriously inferior as a material for building. Stone of the quality that I should have selected (some of which has been used in the Myapoor Regulating Bridge) was much too expensive; and as my estimate of brick masonry is of a more sanguine nature than that of Sir A. Cotton, the heavy expense that the use of good Sewalik stone for the masonry, or even for the floorings and walls of the falls and locks, would have entailed upon the works, determined me on the use of brick.

With reference to the above, I may quote paragraph No. 70 of Colonel Turnbull's Report on the Permanent Head Works Ganges Canal, November, 1862. Colonel Turnbull writes: "Some time before Colonel Rundall's visit to the head-works, Mr. Login was directed to explore the neighbouring hills at Hurdwar, for the very hard, heavy conglomerate adverted to in his report: and having done so, in company with the professor of geology in the Civil Engineer College of Roorkee, Mr. H. B. Medlicott, he ascertained that such stone is only to be found in detached masses along the hill-side, or in irregular deposits, where it

“ lies in its bed, and that the rock adjoining it was
 “ quite unfitted for the proposed work nearer than ten
 “ miles from its site. That the gradient for a tramway
 “ to connect the works with the hills would be 1 in
 “ 13 feet, and that, therefore, quarried stone of 3 to
 “ 5 tons weight, as proposed by Colonel Rundall, could
 “ not be placed upon the works at less than 8 annas
 “ per foot.”

From what I hear, the reason why brick masonry has failed in the falls (or weirs, as designated by Sir A. Cotton) is, that a pressure of water has been brought to bear upon the floorings of a nature far beyond what I contemplated; and I have the best authority for asserting that even in these cases the general character of the brickwork has been proof against the most exaggerated action of the water. Failure has been attendant on badly-constructed work. I am quite willing to agree with Sir A. Cotton that stone is better than brick, as a general rule, but I would prefer good brick to stone of doubtful quality.

Sir A. Cotton is mistaken in supposing that the boulders (or pebbles to which he refers¹) found in the bed of the Ganges and its tributaries have met with the fate that he bewails for the sandstone. I have always been a great advocate for the use of this material, having had before my eyes the gigantic ruins of Badshahmuhal, and the river-face of that palace, the substructure of which was built of boulders (huge masses of this species of masonry, having been undermined, lie prostrate in the bed of the river). A great portion of the solid work of most of the canal buildings in the Khadir have been constructed with this material, whilst the limestone boulders have subscribed to the limit of their extent to the mortar.

The implication that every useful material has been rejected and neglected by me in the construction of the works, is, to say the least of it, not very complimentary.

Fundamental mistake No. 4 is worded as follows :—

“ 4. The whole of the water is admitted at the head, “ so that some of it is conveyed 350 miles to the land it “ irrigates, while it might have been obtained at a “ sufficient level, at a distance, say, of 50 or 100 miles.”

With the strictures conveyed in the first fundamental mistake, Sir A. Cotton states that at two different points on the Ganges, he has been informed that the difference between the level of river-bed and high land is 40 feet. He then attempts to show how, by carrying a canal for $12\frac{1}{2}$ miles, with a slope of 6 inches per mile, he could, by an annicut or dam of 10 feet elevation, supply water for irrigation on surface levels.¹ He now, under the head of his fourth fundamental mistake, illustrates his argument by an imaginary case, where the back-bone of the Doab (or delta, as he calls it) is 50 feet above the bed of the river, where his dam or annicut is raised 15 feet, and where the slope of the canal channel is 3 inches per mile.²

Thus :—

Total difference of level between river and land	50 feet.
Height gained by weir	15 „
	—
	35 „
Ditto, by canal having a less slope than the	
land by $1\frac{1}{4}$ foot per mile, 28 miles, at $1\frac{1}{4}$ =	35 „

In both these cases, it will be observed that the site of the wasteboard of the dam or annicut, whether in that of 10 feet elevation or in that of 15 feet, and the bed of the canal at the point of departure, are on one and the same level. Sir A. Cotton, I presume, therefore, to

¹ P. 49.

² P. 53.

obtain a water supply, contemplates some additional elevation raised on the top of his annicut. The above two examples are intended to show the absurdity of my proceeding for a canal head to Hurdwar, when a supply could so easily have been procured from points so much more accessible. On the 50 feet difference of level (illustration just given) he estimates the cost of the annicut over the Ganges at 5 laks of rupees, and goes into detail of the enormous saving that his plan would have effected. ✓ He states, “that in this case, therefore, “instead of bringing the water, suppose 250 miles from “Hurdwar to 100 miles above Cawnpoor, it would only “have been conveyed 28 miles, and there would have “been a saving of 225 miles of canal against the “construction of a weir. The cost of the latter might “be 5 laks, and that of an excavation of, suppose, 50 “square yards of section, say, at $1\frac{1}{2}$ anna per yard, “or 9,000 rupees a mile, would be, for 225 miles, “20 laks.”¹ I understand from the above, which is not very clear, that Sir A. Cotton proposes to terminate his 28-miles cut at a point 250 miles below Hurdwar; that he estimates the cost of a dam over the Ganges at 5 laks of rupees; and that, having deducted the 28 miles of his excavation from the 250 of mine, he places the cost of the dam against my 225 ($250 - 28 = 222$?) miles of excavation, the one being 5 laks and the other 20 ! What can be the meaning of this ? If he intends to start from the 250 miles, thereby saving all the money expended up to that point in my project, he must place the difference of cost paid in juxtaposition. For instance,—

Sir A. Cotton's dam 5 laks.

Cost of cutting of canal from dam to the end

of the 28th mile (or to my 250th mile) . . . ?

These two items must be set against the cost of my works from the head to the 250th mile.

The irrigation of the whole of the lands above this point would, of course, be thrown out; but General Cotton points out this advantage in so doing—"It would provide for a large additional supply of water beyond what could be obtained from the present head, for it would secure the water draining out of the sands of the river on this 225 miles, besides any flowing into it from the small affluents that water the river in that space."¹

"The same might be done with the Jumna," he goes on to say, "and thus, at a small cost, three or four times the land might be irrigated that is at present provided for. Probably, one or two such additional heads for each of the rivers, Ganges and Jumna, might be cut with advantage."²

Sir A. Cotton's language is obscure, and I may possibly misunderstand him; but there is no questioning the fact that the object that I wished to attain of irrigating certain districts is entirely ignored, and a project of his own is made the vehicle for strictures on mine. It is unnecessary to recapitulate my objections to Sir A. Cotton's schemes; these are stated in my reply to his first fundamental mistake. It will be found more easy to propose weirs and dams on the sandy tracts of the Ganges and Jumna than to execute them.

The fifth and last fundamental mistake is as follows:—

"5. There is no permanent dam across the river at the head of the canal, so as to secure the supply of water, but temporary works are thrown up after every monsoon, which are liable to be swept away, and have been swept away at the very time when they are most wanted."

In the canals in the North-West Provinces, the

¹ P. 54.

² *Ibid.*

supply for which is drawn from the great rivers at their debouche from the mountains, this supply is obtained in the manner noticed by Sir A. Cotton, viz., by temporary spurs and dams thrown out into the main river. No doubt that this is a very imperfect method of securing the object in view; but if successful, as it has been on the Jumna, the device is, at any rate, an economical one. Even on the Ganges Canal, the annual cost, estimated at 20,000 rupees (which represents a capital of 4 laks), is economical, as far as the mere work is concerned. In adopting this course on the Ganges Canal, however, and being guided by experience gained on the Jumna, I was by no means satisfied that, in dealing with such large masses of water, works of a more permanent nature would not ultimately be called for. This was a matter left to be determined by experience. I am not in the habit of jumping at conclusions, and putting the Government to expenses which are not proved to be necessary; and I, therefore, left this "fundamental mistake" to be corrected by my successors, whose observations on the difficulty, or otherwise, of maintaining the supply by the usual method adopted in these provinces, would lead them ultimately to arrive at satisfactory conclusions. The question, however, of throwing a permanent dam or annicut over the Ganges at the point desired is, by no means, so simple as Sir A. Cotton imagines. His experience, great as it is, is connected with rivers of an entirely different description to that of the Ganges in its debouche from the Sewaliks. Here we have heavy slopes with large masses of water pouring down with overwhelming violence; there he has much larger bodies of water, but on very much smaller slopes in connection with a true delta. Sir A. Cotton gives the following statement of discharges:¹—

Ganges	25,000,000 cubic yards per hour.
Godaveri	200,000,000 ,,
Kistna	160,000,000 ,,

Or, translated into cubic feet per second—

Ganges	187,500 cubic feet per second.
Godaveri	1,500,000 ,,
Kistna	1,200,000 ,,

And states that the construction of the dam over the Ganges, at the level head, “is still put off, apparently “under the strangest fancy that such a work is one “of most serious difficulty, though it is nothing to “the works of the kind that have been executed in “Madras.”¹

I am not at all satisfied with arbitrary statements of “millions of cubic yards per hour,” without knowing on what they are based. It is possible that the amount of discharge during the monsoon, at the point where the permanent dam at the Ganges Canal head is to be built, may be correct. Nevertheless, small as this is in comparison with those stated by Sir A. Cotton, as appertaining to the Godaveri and Kistna, the Ganges has a slope of bed far beyond its Madras compeers. This slope makes all the difference; and although I believe a permanent dam may be constructed without fear, and I have no doubt that if it is so it will be of infinite benefit to the canal, and of great relief to the mind of the engineer, the cost of the work will be, not as Sir A. Cotton states,² 30,000*l.* or 40,000*l.*, but, as estimated by the officers on the spot, at nearly double that sum; and, if cut stone is used, as demanded by Sir A. Cotton, the work will cost very much more. The Ganges, moreover, will not quietly submit to discipline of the nature proposed, and breaches will annually occur at points not

very easily to be approached. Although, therefore, I admit that a permanent dam is desirable, and that the annual expenses that this will entail are far preferable to interruption to the canal supply, I consider that we have used a wise discretion in not calling upon the Government to spend large sums of money without having ascertained beforehand the positive necessity for so doing.

This concludes my remarks on the five fundamental mistakes, or, as Sir Arthur Cotton calls them, the greatest fundamental mistakes in the project.

I shall now proceed to reply *seriatim* to the different minor mistakes of which Sir Arthur Cotton notes fourteen, prefacing them with the following paragraph:—

“But besides these fundamental mistakes in the projection, there are the following minor, but still important ones:”—

Minor mistake No. 1.—“All the weirs are made of a length corresponding with the full breadth of the canal, while they need not and ought not to have been more than one-third of that length, entailing a more than double expense in their construction, besides other destructive evils which will be more fully explained.” This is a question so intimately connected with “No. 4 Minor Mistake,” that deals with the slope of the canal bed, that I shall merely remark that the breadth of the falls is *considerably more* than the breadth of the canal channel. In the larger falls there are eight openings or water-ways of 25 feet each; each opening has arrangements at the upper level or sill for the application of planks or sleepers to a depth or height of 7 feet. The fall on the lower face is divided into four chambers by walls, so that in the event of repair being required to a chamber flooring, the object can be effected by closing

power of opening and closing these upper water-ways by sleepers gives the means of regulating the passage of water on the falls, and of guarding an injured chamber against further injury. The design contemplated not only great strength to overcome the effects of such large masses of water, but ample means for providing against accident by the separate chambers. Sir A. Cotton observes that the breadth might have been reduced to one-third,¹ and that the works have cost more than twice what they ought to have done.² A water-way of 66 feet in width (or one-third of the dimensions given) would have been a somewhat confined passage for so large a volume of water, laying aside the fact that we should have been deprived, under such a width, of alternative channels, and of the means of maintaining the canal supply should any accident happen to the work. More will be said on the subject of these falls when I discuss the question of the slope of bed.

Minor mistake No. 2.—"These weirs (falls) are placed
 " on the direct line of the canal, while the navigation
 " lines and the locks are placed out of the direct line,
 " thus compelling the whole of the traffic to go round
 " instead of the irrigation water."

I understand by this that Sir A. Cotton would have given a turn to the main canal at each fall, and allowed the navigable channel to proceed in the straight direction. In other words, the main body of the water would have been made subordinate to a little channel. Sir Arthur Cotton writes after this fashion in disapproving of my plan :—" There is no reason for this, the navigation
 " was the thing to be cared for ; it was a matter of
 " no consequence that the water should be led round
 " by a circuitous route,"³ &c. The simple consequence of leading large masses of water round an object, or

turning them from their course, is to lead to very serious action upon the channel. At any rate, I have no doubt that the plan adopted was the proper one—viz., to carry the main channel and large body of water direct, with the navigable channel, or small body, in the circuit. Sir A. Cotton goes on to say, “that the boats now have “to get out of the current which leads direct to the “weirs, and to turn into the side channel, and, of “course, not without danger. Some boats have thus “been carried over the falls, and several lives have been “lost.”¹ Had Sir A. Cotton referred to my report, and to the plans that accompanied it, he would have found in the former at pp. 297, 311, 312, vol. ii., and in the latter at plan No. 30, also p. 304, vol. i., that full attention had been given by me to the danger to which he refers. It would have been impossible, had my project been followed, for either boats, rafts, or anything else, to go over the falls; the bridge of boats, for which arrangements were made in the permanent buildings on the right and left of the main channel below the mouth of the navigable line, would, had they been in position, have prevented accident. The loss of life, and the absence of these boat-bridges, are facts which are entirely new to me.

Minor mistake No. 3.—“The whole cut has too great “a fall in its bed—from 15 to 12 inches per mile— “which, with a depth of 10 feet which it was intended “to have, gives a current of $2\frac{1}{2}$ or $2\frac{3}{4}$ miles an hour, “which is too much both for the bed and banks of the “canal and also for effective navigation.”

Sir Arthur Cotton considers the above as a “minor, although important mistake,” whereas it ought to have been placed at the head of his great fundamental ones. Upon it has depended not only the interruption to irriga-

tion but the injury to the masonry falls, the constant repair of which has led to repeated stoppages of the supply, at times, unfortunately, when irrigation was most demanded. Sir A. Cotton has indorsed the view taken by the public press, that the great depth of excavation of the canal channel was the cause of difficulty in working the canal for irrigation; whereas he must have well known, by visiting the works, that the want of irrigation was caused by the want of water, arising from the frequent stoppages to the supply, for the purpose of repairing the falls.

I have no hesitation in admitting that, with so large a volume of water running at such great depths, I have projected the canal bed on too heavy a slope; it has been the cause of all the disasters which have occurred, the source of constant anxiety, and it has brought the canal into a position which in all probability is not exaggerated by Sir A. Cotton.

In self-defence, however, I must explain both to the readers of the Pamphlet and the Report, that the projection of the slope of 15 inches per mile was determined on reasonable grounds, viz., that high as the slope was, artificial means might be applied so as to render the effects arising from it innocuous. The means which I adopted were, strengthening the floorings and tails of bridges by heavy and extensive boulder-work, and by reducing the evil to a minimum by offering as many checks as possible to retrogression of levels (*Ganges Canal Report*, vol. ii. p. 158). These artificial means have entirely failed, and the consequence has been that the great slope given to the canal bed has acted in its fullest effect.

I must now explain the principles on which my line of action was determined. In calculating the area of a section required for the carriage of a given quantity of

the alternative of a narrow channel with a rapid slope, or a wide channel with a small slope. The first may be maintained by artificial expedients, the latter is independent of them; the first can be constructed at a moderate cost, the latter at a very high one. For instance, in the case of the Ganges Canal from the Roorkee bridge to the Bolundshuhur branch-head, say a distance of 91 miles, the slope of country is $177\frac{3}{4}$ feet; by the projection of slope which I gave to the canal bed of 15 inches per mile, I obtained an open canal, with a moderately wide excavation, with a superfluous fall of 64 feet, which was overcome by eight falls of 8 feet each. The same line projected on a low slope, say that determined by Sir A. Cotton of 3 inches per mile, would demand an excavated channel of much greater width, with a superfluous fall of 155 feet, to be disposed of by masonry descents, so that the difference in cost of the low and the high slope would be enormous. I allude to the above arrangements with reference to the channel, with no intention of excusing myself, but to show that the grounds on which I acted were reasonable.

We have never before dealt with such large masses of water in irrigation canals where a constantly running stream is indispensable. It is with these large masses that our difficulties have arisen. I see no remark in Sir A. Cotton's report tending to show that he looked upon them as affecting the project; so far from it, that he proposes¹ a depth of 18 feet of water without the slightest hesitation, and without the most distant idea of having difficulty in dealing with it.

From what I have said above there will be no difficulty in understanding that the action on the falls depends on the current obtained from the rapid slope of the bed; take away that rapid slope, and the evil ceases.

The method which I adopted of dividing the head of the falls into eight separate bays of 25 feet each, with grooves adapted to the establishment of sleepers, offered the means of reducing the width of the water in its passage over the falls to a dimension less even than that demanded by Sir A. Cotton.

I look to the improved plan of falls adopted in the Baree Doab Canals, rather than to the weak projections of Sir Arthur Cotton. I believe that the fall in the form of an ogee which I have adopted requires modification, and I have no doubt that this will be made with due consideration to the masses of water with which we have to contend. With regard to the use of slabs of stone on the floorings in substitution of brick on edge, the only objection is expense. The country below Roorkee is far distant from quarries, and the cost of stone will be very heavy; nevertheless, I would recommend stone, and, if procurable, slabs from the quartz rock of Delhi.

In closing this part of the subject, and in referring to the falls and their brick floorings, to which Sir A. Cotton objects so strongly,¹ I must observe that to remedy the defect of heavy slopes, sleepers or planks, to which I have before alluded, have been permanently established at the heads of the falls, so as to reduce the slope above stream.² This remedy, while averting one danger, has given birth to another not less serious. The increased head-water has severely tried the works, and some of them have given infinite trouble and anxiety. No doubt that badly executed masonry work has been brought into prominent relief, and that those works with bad brick masonry have suffered; but if there were no other mark that Sir A. Cotton's condemnation of brickwork is too sweeping, it would be shown by the fact that where pre-

cisely similar falls have been well built, they have stood uninjured.

Minor mistake No. 4.—"The canal has been terminated at Cawnpoor instead of being carried on 120 miles to Allahabad, where the Jumna and Ganges and the river navigation begin to be effective throughout the year."

As my project was for the irrigation of the Doab as far south as Cawnpoor and the districts lying parallel, a navigable line to Allahabad has not much to say to it.

Minor mistake No. 5.—"The slope of the canal is continued to the end at Cawnpoor, so that to keep the navigation open, there must be a large body of water continually pouring to waste in the river."

I must repeat that my project is for irrigation, and as such, it is indispensable that there should be a running stream to the lowest rajbaha head, and to obtain this stream, I imagine that slope is necessary. It is only when the demands for irrigation are small that water flows to waste in the river. Had Sir A. Cotton visited the terminus during a season of drought, he would have found the canal dry, in all probability, at its extreme end,¹ it being a rule in the canals in the North-West Provinces to sacrifice navigation (which is a mere secondary object) to the wants of the agriculturist in times of drought.

Minor mistake No. 6.—"The bridges are so low as to prevent a fully loaded boat passing under them."

This is only true as regards the lower half of the canal; the bridges on the upper do not, I believe, inter-

¹ In seasons of heavy drought a system of rotation is adopted (*tateel*, "turning out"), which system is given for irrigation to every village in

fere with the passage of boats. On the lower part, my minimum height between high-water mark and the soffit of the arch was 5 or 6 feet, ample for the passage of such boats as were used on the canal. The high-water mark of my project, however, has been, in late years, much exceeded—I hear, to the extent of 2 feet in the Cawn-poor terminus, so that there must have been great interruption to the passage of boats. The quantity of silt brought down from the canal bed south of Roorkee has no doubt been deposited in different parts of the canal bed, and acted in elevating the high-water mark. Viewing the question, however, as Sir A. Cotton views it, the bridges, no doubt, are opposed to general navigation.

Minor mistake No. 7.—“The towing-paths are not
“carried through the arches of the bridges, so that the
“line has to be thrown off at every bridge, that is, at
“every 3 miles.”

Both this and the last mistake would, no doubt, have been serious ones had navigation been the leading feature of the project, but this was not the case (*vide Ganges Canal Report*, vol. ii. pp. 319–321).

Minor mistake No. 8.—“The lock-channels have
“such sharp curves that boats of the length of the locks
“cannot pass through them.”

The lock-channels leave the main line at an angle of 18 degrees (*vide* plan 30 of the atlas). I was not before aware of sharp curves existing, nor of the defect pointed out by Sir A. Cotton (*vide Ganges Canal Report*, vol. ii. p. 308, *et seq.*)

Minor mistake No. 9.—“No arrangement has been
“made for the disposal of the silt.”

None further than to pass it off by the escapes and termini.

“ navigation lines between the different main branches,
 “ so that boats can only get *across* the tract by going all
 “ the way up to the point where the branch and the
 “ main line divide.”

This is treating the project as one for navigation, which it was never intended to be. My project, however, alludes to a navigable channel from Moradnuggur to the Jumna, or to the Hindun (vide *Ganges Canal Report*, vol. i. p. 219).

Minor mistake No. 11.—“ The Solani aqueduct is
 “ made of the full breadth of the canal above, and of the
 “ full length of the breadth of the river below, whereas
 “ it might have been made of $\frac{1}{3}$ of the breadth of the
 “ canal, and its length of about $\frac{1}{2}$ of the breadth of the
 “ river, reducing its cost to perhaps $\frac{1}{4}$ or $\frac{1}{5}$ of what it
 “ has been.”

In chapter ix. of my *Ganges Canal Report*, vol. ii. page 411, I have entered fully into the merits of the questions now brought forward by Sir A. Cotton. The width of water-way for the Solani was determined on observations carefully made during heavy floods, and, with reference to the catchment basin of the river, it has nothing whatever to do with the width of the river. The river as now existing is limited to the water-way of the aqueduct, whereas, previously to the establishment of this building, its course was in quite a different direction. Rivers, or mountain torrents like the Solani, do not run on one defined course ; they play all sorts of vagaries on a wide-extended Khadir, now showing themselves on a wide shallow bed, then in a number of minor channels ; and this was the character of the Solani before it was restricted to its present course. From the authoritative way in which Sir A. Cotton writes, I presume that he has looked deeper into the question than I have, and that

having well examined the merits of the case. His method of writing, however, conveys an impression that, without any scientific inquiry, I had determined the width of the water-way by the existing width of the river, and that the width of the aqueduct channel had also been obtained by a similarly rude and simple process. Sir Arthur Cotton, however, is here mistaken. Both the width of river water-way and the width of canal water-way on the aqueduct have had much care, thought, and attention devoted to them; and this does not deserve to be treated in the *ad captandum* language of Sir A. Cotton's Report. It was indispensable that the Solani aqueduct should be placed beyond the reach of accident from the most violent floods, as upon the maintenance of this work depended the maintenance of the supply. I do not think, that, with reference to the volume that the Solani Valley throws upon the works, and especially to floods like those of 1845, the water-way could, with safety, be diminished.

The water is conveyed on the aqueduct by two channels of 85 feet each, each channel being constructed on separate foundations; the channels have sleepers adapted to them, so that in case of accidents or danger to one of the chambers an alternative line is offered, by which the supply is maintained in the other. I did not consider myself justified in attempting a rapid run of water over this elevated embankment, nor would this have suited the plan of the double chambers, which I believe to be a most valuable adjunct to the undertaking. I do not think, moreover, that a body of water equal to 6,750¹ cubic feet per second could, on an embankment at an

¹ The Thames, in the parts removed from the influence of the tides, on the average, has a volume equal to 1,357 cubic feet per second (*vide* Weale's *London and its Vicinity* p. 7), or one-fifth of the volume of the Ganges Canal.

elevation of 27 feet, be allowed to run on extraordinary velocities; but here again I find that Sir Arthur Cotton lays no weight on masses of water like those I have to deal with. He gives me,¹ as an example that I might well have followed, the Gunnarum Aqueduct—a work carried over a minor branch of the Western Godaverī—the channel of which is 22 ft. in breadth, and which has a capacity of channel equal to the carriage, at a depth of 4 feet, of from 500 to 650 cubic feet a second!—*Vide* Baird Smith's *Report on the Cauveri, Kistna and Godaveri*: Smith, Elder & Co., 1856.

✓With reference to the Gunnarum Aqueduct, the late Colonel Baird Smith, in pp. 114–117 of the report above noted, draws attention to points which are very suggestive, as bearing upon Sir Arthur Cotton's strictures upon my operations. Colonel Baird Smith says:—"It appears
 "to be possible to secure foundations on the rivers of
 "Southern India, with their very low slopes, by means
 "which, with our own experience of the rivers of
 "Northern India, we would be justified in pronouncing
 "utterly inadequate, and with which, in fact, we would
 "never dream of operating, since they would inevitably
 "fail on the first serious trial. I therefore conclude
 "that, so far as the foundations are concerned, previous
 "experience in other and similar localities is sufficient
 "to warrant their being pronounced trustworthy. But
 "the provision for the passage of the floods seemed to
 "me inadequate. Within a few months, or possibly
 "weeks (for I forget the precise date) after the aqueduct
 "was finished, a flood rose, as I understood, not less
 "than 5 or 6 feet over the level of the tops of the parapets, thus burying the whole structure under water.
 "The height of the flood must have been about 30 feet,
 "and it was no doubt an extraordinary one; but not so

¹ P. 59.

“ much so as to place it beyond the region of contin-
 “ gency, for which, in projecting such works, it is neces-
 “ sary to make some adequate provision. The sectional
 “ area of channel for such a flood, as provided by nature,
 “ is, approximately, about 72,000 square feet; that pro-
 “ vided by the engineers is considerably over-estimated
 “ at 30,000 square feet. It is only necessary to look at
 “ the elevation of the aqueduct, and to note the propor-
 “ tion between the solid and permeable surfaces pre-
 “ sented thereby to the stream, to make it self-evident
 “ how serious an obstruction to the current the work
 “ must be in all considerable floods, but especially in
 “ those where the flood-level rises high on the parapets.
 “ I must confess my own conviction to be that this
 “ aqueduct will be a constant source of anxiety, and that
 “ the probabilities are in favour of the repeated occur-
 “ rence of formidable accidents to it. That this antici-
 “ pation is not imaginary has been proved by the expe-
 “ rience of the past season, and I quote a few words
 “ from a letter under date 19th August, 1853, from an
 “ officer intimately connected with the works, showing
 “ that already the dangers to which the structure is
 “ exposed have exhibited themselves in a very serious
 “ form :—‘ The great aqueduct, by the way, has received
 “ ‘ considerable damage, the high and heavy side wall
 “ ‘ having broken and fallen flat upon three of the arches,
 “ ‘ which are thereby cracked considerably, and one of
 “ ‘ them very badly. This was caused by very high
 “ ‘ freshes, which come down at an unprecedentedly
 “ ‘ early period. The Vegaishwaram head sluice (at the
 “ ‘ annicut or dam) was also partly destroyed; the ruins
 “ ‘ of its adjoining lock, I believe you saw. The Kistna,
 “ ‘ also, rose to a prodigious height, and flooded vast
 “ ‘ tracts in Masulipatam and Guntoor, so that the
 “ ‘ people had to mount on the roofs of their houses

“ ‘ and on carts for safety. There was a regular river
 “ ‘ 9 miles wide, north of Bezwarah, where the land dips
 “ ‘ from the banks of the Kistna.’

“ I have added details not directly connected with
 “ the aqueduct, with the view of showing that the floods
 “ on this occasion were evidently paroxysmal, being
 “ rather grand *debacles* of water than even freshes of the
 “ order termed extraordinary. I do not advocate perfect
 “ provision against such *debacles*, for the expense would
 “ be enormous; and it is preferable, I conceive, to run
 “ the risk of such very rare events, and to be prepared
 “ to repair the injuries done to them, rather than to
 “ execute works which may not be required more than
 “ once or twice in a century, and the provision of which
 “ would prove, in all probability, a total bar to progress,
 “ by the gigantic scale of expenditure it would necessi-
 “ tate. It is because the aqueduct seems to me to be
 “ inadequate to its task of passing these high floods
 “ which often occur, that I have expressed the foregoing
 “ opinions; and though I have a high respect for its
 “ projector, it would, I conceive, be shrinking from my
 “ duty, were I not to express them frankly. For occa-
 “ sional accidents, when such rivers as the Godaveri are
 “ being dealt with, every reasonable person will be pre-
 “ pared, and will view them with due consideration; but
 “ it is to more than common risks that a work with the
 “ proportions of the aqueduct is exposed; and I see but
 “ little chance of the consequences being evaded while
 “ these proportions are maintained.”

I must have reasons, at any rate, given me before I am brought to believe that I have been wrong in my projection of the Solani works; and I find none in Sir Arthur Cotton's statement.

Minor mistake No. 12.—“ The breadth of the canal at

“such as there would be if the navigation were in an effective state.”

With this my irrigation project is not concerned.

Minor mistake No. 13.—“The slope of the sides of the canals are much too steep.”

I do not agree with Sir A. Cotton.

Minor mistake No. 14.—“There is no communication between the canal and the river at Cawnpore; for though there are double locks, the gates of the lower ones were not in repair. I am credibly informed when they were in repair, boats were not allowed to pass backward and forward, but if they entered the canal were compelled to remain in it, because, as I was informed, they often injured the plaster on the lock works.”

To this I have no reply.

Having now gone patiently through the whole of Sir Arthur Cotton's Report, and replied to his censures with as much temper as I could be expected to maintain under such an infliction, I shall take the liberty of making a few remarks bearing on the general question.

I have in the early part of this paper stated under what circumstances General Sir A. Cotton wrote his Report. I heard accidentally of its existence early in November, and immediately applied to the secretary of the East India Irrigation Company for a copy, the report having been read by my correspondent in India in print. The secretary informed me that the document had never to his knowledge been printed; that it was a private paper¹ for the use of his Company, and that if it had been printed, this must have been done in India. He telegraphed to Sir A. Cotton to know whether he might

¹ The MS. in my possession is headed—*Private Memorandum, by*

provide me with a manuscript copy of the Report. This being acceded to, the secretary very kindly not only sent me a copy, but copies of his letter to the Government of India and to the Financial Member of the Governor-General's Council. The paper, therefore, came before me long after it was issued. I received it on the 13th of November, 1863.

So far for the history of the Report. Now to my remarks upon it; the delay of which is sufficiently accounted for by the above explanation.

One of the most extraordinary facts connected with Sir A. Cotton's censure is, that he declares that I had no reason for proceeding to Hurdwar and its neighbourhood for a head for the canal; that by going to the higher regions I had led Government into expenses in connection with the mountain torrents which were preposterous; and that in so doing I had committed an error which he considered to be the leading fundamental mistake—that is to say, the first of nineteen mistakes that I had committed in the design. He points out that the proper site for the head of the canal is from 50 to 100 miles south of Hurdwar, and below the junction of the Solani River with the Ganges.

Now we must inquire on what grounds Sir Arthur Cotton has made this declaration. It would fairly be supposed that he had examined the topographical features of the country, and have carefully estimated the value of the Ganges River in its connection with the shingle tracts and the sandy bed of the Khadir; that he had looked carefully to the nature of the rivers, and to the contour and character of the high country in the neighbourhood, with reference to those rivers, before he came to any decision on the subject, or at any rate before he became directly antagonistic to plans which had been drawn up and matured

naturally have been supposed—but what is the fact? Sir Arthur Cotton paid a flying visit to the Ganges Canal works, and (to use his own words) “I was informed by “an officer of the Canal Department that he had taken “the level from the Futtigurh branch of the canal to “the neighbouring bed of the Ganges in two places, “and found it 40 feet in each.”¹ Without the slightest hesitation or scruple, Sir A. Cotton, upon hearing this, rushes at the conclusion noted in his Report, gives his high name to a summary condemnation of all my proceedings, and forwards to the secretary of the East India Irrigation Company a Report professing to be his deliberate views on the fundamental mistakes of my projection. In looking carefully through Sir A. Cotton’s Report, I can find nothing but the statement made by the departmental officer to warrant his conclusion; I can discern no sign by which he has been otherwise guided.

The point on the Ganges from whence Sir A. Cotton proposes to draw off his supply for the canal is by no means clearly indicated. I find that he gives² as a terminus for a line of 28 miles in length a point 250 miles below Hurdwar, but how he leaves the Ganges on these conditions, I have not the most remote idea. He refers also to making a cut 12 miles in length.³ I presume that this must be intended to leave the Ganges not far south of the confluence of the Solani, but although I can’t pretend to strict accuracy as to the precise level of the Ganges at that point, I believe that a cut having a slope of 6 inches per mile would not fulfil Sir A. Cotton’s conditions in a shorter distance than 50 or 60 miles. He refers in the latter part of his Report⁴ to heads taken off from the Ganges and Jumna 200 and 300 miles below the confluence of the Solani. In

another place he states that by making a new head to the canal below the confluence of the Solani, “far less expense will be incurred than by correcting the works on the canal above Roorkee. If these works, with the help of slight alterations, will have a depth of water in the canal of 3 feet instead of 7 feet, as at present, the cost of cutting 12 or 15 miles to form a new head will be less than the substitution of new stone weirs for the present brick ones. *The weirs across the Ganges will, of course, be nearly the same, whether built at Hurdwar or below the Solani.*”¹

How can this be? Is it to be understood that the cost of a dam, built on the deep and wide sandy bed of the Ganges, below the confluence of the Solani, will be the same, or nearly the same, as that constructed at Hurdwar over the stony bed of the river? To this conclusion we are inevitably led by the above extract; yet elsewhere² Sir A. Cotton appears to think that the absence of quarries in the proximity of this lower dam might lead to additional expense.

The Hurdwar dam is estimated by Sir A. Cotton at a cost of from 30,000*l.* to 40,000*l.*³

Looking further into the report,⁴ the dam below the confluence of the Solani is estimated at 5 laks of rupees; and in the estimate appended to the report appears the following item:—

“New head and weir near the Solani, 100,000*l.*”⁵

This includes both dam and cut from the river. These statements are somewhat contradictory.

In the early part of his Report, Sir A. Cotton states that if matters had been properly conducted, the works “might have been yielding 20 or 30 per cent., or much more, for the last ten years.”⁶ Again he says:

¹ P. 53.

² P. 49.

³ Pp. 51–54.

⁴ P. 54.

⁵ P. 51.

⁶ P. 51.

“ From the mere mention of these defects of projection,
 “ it cannot but be understood how it is that this work,
 “ in a tract of country with such prodigious natural
 “ advantages, has been so unproductive for seventeen
 “ years from its commencement.”¹

The water was only passed over the Solani aqueduct in a small body in 1854; and Lord Hardinge's order to carry out the works was only passed in 1847, that is to say, sixteen years ago!²

In smaller matters, Sir A. Cotton is equally unsatisfactory. For example,—The supply of the Ganges Canal he states to be 8,000 cubic feet per second;³ whereas the whole of my calculations for discharge and distribution are limited to 6,750. In detailing the width of the Solani aqueduct, he states it to be 66 yards;⁴ whereas it is 170 feet, or 56 $\frac{2}{3}$ yards. His calculation of discharge of rivers is founded on what? Millions of yards per hour may be easily written, but not so easily accepted by those who require definite data. A calculation for loss by evaporation on a canal 40 yards wide, of 2 cubic yards per hour, which I observe in his Report,⁵ is one of those extraordinarily cool dicta which defies all inquiry.

In the pamphlet,⁶ Sir A. Cotton states that the last 20 or 50 miles of the canal above Cawnpoor ought to be reduced to dead levels by locks. In his Report⁷ this is

¹ P. 50.

² The ground was actually broken on the 16th April, 1842, under orders from the local Government; but it was not until the report of the sanitary committee had been received, and the inquiry as to the effect of the abstraction of the required supply for the canal upon the navigation of the Ganges had been completed, that the supreme Government determined, in 1847, on prosecuting the works to completion.—(Vide *Ganges Canal Report*, vol. i. p. 68.)

³ P. 50.

⁴ P. 59.

⁵ P. 58.

changed to 30 or 40 miles ; but he states that the dead level is indispensable for navigation. Now, whether there are 20 or 50 miles of still water, it must be borne in mind that irrigation was carried down by me to within a very short distance of Cawnpoor, for the purpose of the tract of land lying between the Pandoo and the Ganges ; and as, on my projection for the discharge for irrigation, 8 cubic feet per second were given for each mile, it would follow that for 20 or 50 miles in length we should require a running stream of from 160 to 400 cubic feet per second. Unless Sir A. Cotton means that branches for irrigation are to be taken off from the canal to the right and left, above the 20 or 50-mile point, leaving the main line as a system of reservoirs, it is difficult to understand how water is to be supplied. Without a *running* stream, as Sir A. Cotton knows, I presume, irrigation cannot be maintained ; and when the supply of water is limited, as it is on the Ganges Canal especially, at a distance of upwards of 360 miles from its source of supply, if navigation is to be insisted on, it will be at the sacrifice of irrigation.

The *problem* to be solved was, the delivery of 6,750 cubic feet of water per second on the high lands of the Doab, and the carriage of this large body of water for the purposes of irrigation to a distance of 360 miles, without any additional supply being available, on the whole length of its course. The *difficulty* consisted in carrying that great mass of water across the Ganges Khadir and its numerous mountain torrents, and in regulating the distribution of the water by a channel so adapted to the required discharge, that every mile on its course might be fairly irrigated. I may observe that the line runs between $29^{\circ} 37'$ and $26^{\circ} 29'$ north lat., and, as will be

lead to complicate a design which is otherwise sufficiently complicated.

Accepting Sir A. Cotton's views, that water can be taken from either the Ganges or Jumna from any point of their course with the greatest facility, and that the nature of these rivers offers no impediment to drawing supplies from them, the difficulties attached to the problem are reduced to a minimum. But there are grave reasons for denying Sir A. Cotton's views. Experience is against them, and the most anxious observations made by myself and others tend to show that the character of the beds of these rivers, below the shingle tracts, is opposed to them. I believe that, at the sacrifice of large tracts of valuable land in the valleys of the Hindun and West Kalli Nuddi, water might be collected in reservoirs for the purpose of giving a small additional supply at a point to the West of Meerut; but this would be gained by the very dangerous experiment of constructing permanent dams over the valleys of these rivers at an enormous cost, the sills, or wasteboards, of the dams being raised 15 and 25 feet respectively (see *Ganges Canal Report*, vol. i. p. 10). With this exception, *I am still of opinion that the Ganges Canal has no means of supply further than from the head above Hurdwar*; and I cannot, from Sir A. Cotton's speculations, and the conclusions arrived at from them, consider that he has weakened my views.

To the excess of slope in the bed of the main channel I refer with the greatest regret. The remedy, however, appears to be rather in the division of the great body of water, and thereby in diminishing the effects of its action, than in the continuance of the existing channel as a single line. From the head to Roorkee in the presence and proximity of so much material there can be no difficulty. Imagine in putting the present channel in a perfect

state of efficiency. From Roorkee to the Bolundshuhur head the volume of water might be divided so as to pass onwards in two independent channels, the one continuing on the line now in existence, the other in a westerly direction, or that marked by the Deobund Rajbuha; these two streams would unite at the Bolundshuhur head. The amount of volume passing down the two lines would be regulated by the requirements of the Futtigurh branch, and might on a general estimate be calculated at 3,750 cubic feet per second for the eastern, and 3,000 for the western. The bed of the eastern line would require to be protected, and the slopes to be remodelled. By an arrangement of this sort the capacities of the two channels would be brought to a manageable dimension, while it would offer the inestimable advantage of an alternative line for securing a supply of water to the southern divisions. From Bolundshuhur to Nanoon the slope in the main channel I presume will require modification, and I should be inclined to adopt the same expedient of dividing the volume of water either by the Bolundshuhur branch head, or by carrying lines of irrigation on each side of the main channel.

I am much in favour of reducing the present volume of water in the main canal. My belief is that the volume of water is too great for an artificial channel carried through a soil like that through which it passes below Roorkee. With so many falls, and with so large a body of water passing over them, perpetual repairs and interruption will inevitably occur, let the slope be reduced to any extent. By the division of the waters this will be avoided; and the evils of accident on one line will (as far as supplies for irrigation to the south are concerned) be neutralized by the existence of an alternative line.

I do not advert to Sir A. Cotton's schemes any further than to protest against—1. His dams and anni-

cuts over the Jumna and Ganges below their shingle tracts. 2. His views of carrying the water of the main line of the canal above the level of the country. The first is visionary, and the second is quite unnecessary for the purposes of irrigation ; in a sanitary point of view it is utterly destructive.

One word in conclusion : Sir A. Cotton's Report has forced upon me a reply, not for my own justification only, but as a duty to the Government whom I have served so long, and I have no hesitation in saying, so zealously. I have no affection for controversies, nor will I be drawn into them ; here, as far as I am concerned, the matter drops.

It will be said that the Report is a private paper, drawn up for the use of the East India Irrigation Company, and not a public Report, deliberately submitted ; as, however, it has been forwarded to the Government of India, and as by some means or other it has been printed, the Report is on the high road to become public.

APPENDIX.

PRIVATE MEMORANDUM BY MAJOR-GENERAL SIR ARTHUR COTTON, UPON THE GANGES CANAL.

[Transmitted to Sir C. Trevelyan, Financial Member of the Council of the Governor-General of India, by the Secretary of the East India Irrigation Company, accompanied by a Letter dated July 27, 1863.]

THIS great work, even as it has been projected, would have paid a large direct interest, besides far greater benefits to the landowners and public generally, had it been carried out to completion, and it will do so still, if completed. It has already saved tens of thousands of lives, and an amount of property probably exceeding its cost, during the late famine.

There are, however, the greatest fundamental mistakes in its projection, which have made a prodigious difference in the results. They are as follow:—

1st. The head of the canal is placed too high up, above a tract which has a very great and inconvenient fall, and in which there is a very heavy drainage from the sub-Himalayas, across which the canal has to be carried.

2nd. The whole canal has been cut so as to carry the water below the level of the surface, entailing a vast unnecessary excavation, and keeping the water below the level at which it is required for irrigation.

3rd. The whole of the masonry are works of brick, while the most suitable stone for hydraulic works is procurable in the sub-Himalayas; this is a most inexplicable mistake.

4th. The whole of the water is admitted at the head, so that some of it is conveyed 350 miles to the land it irrigates, while it might have been obtained at a sufficient level at a distance of say 50 or 100 miles.

the canal, so as to *secure* the supply of water, but temporary works are thrown up after every monsoon, which are liable to be swept away, and have been swept away, at the very time when they are most wanted.

The first four of these fundamental mistakes have caused the cost of the works to be probably three times what they need to have been, consequently have increased the time of execution threefold ; so that they might have been yielding 20 or 30 per cent., or much more, for the last ten years, instead of being to this day an unpaying project, with interest accumulating for ten years.

But besides these fundamental mistakes in the projection, there are the following minor, but still most important, ones:—

1st. All the weirs are made of a length corresponding with the full breadth of the canal, while they need not, and ought not, to have been more than one-third of that length, entailing a more than double expense in their construction, besides other destructive evils, which will be more fully explained.

2nd. These weirs are placed in the direct line of the canal, while the navigation line and the locks are placed out of the direct line, thus compelling the whole of the traffic to go round instead of the irrigation water.

3rd. The whole canal has too great a fall in its bed, from 15 ins. to 12 ins. per mile, which, with a depth of 10 feet, which it was intended to have, gives a current of $2\frac{1}{2}$ or $2\frac{3}{4}$ miles an hour, which is too much both for the bed and banks of the canal, and also for effective navigation.

4th. The canal has been terminated at Cawnpoor instead of being carried on 120 miles to Allahabad, where the Jumna and Ganges unite, and the river navigation begins to be effective throughout the year.

5th. The slope of the canal is continued to the end at Cawnpoor, so that to keep the navigation open there must be a large body of water constantly flowing to waste into the river.

6th. The bridges are so low as to prevent a fully loaded boat passing under them.

7th. The towing-paths are not carried through the arches of the bridges, so that the line has to be thrown off at every bridge, that is, at every three miles.

8th. The lock channels have such sharp curves that boats of the length of the locks cannot pass through them.

9th. No arrangement has been made for the disposal of the silt.

10th. There are no connecting navigation lines between the different main branches, so that boats can only get across the tract by going all the way up to the point where the branch and the main line divide.

11th. The Solani aqueduct is made of the full breadth of the canal above, and of the full length of the breadth of the river below, whereas it might have been made of one-third of the breadth of the canal, and its length of about one-half of the breadth of the river, reducing its cost to perhaps one quarter or one-fifth of what it has been.

12th. The breadth of the canal at the lower end is much too small for a large traffic, such as there would be if the navigation were in an effective state.

13th. The slopes of the sides of the canal are much too steep.

14th. There is no communication between the canal and the river at Cawnpoor ; for though there are double locks the gates of the lower one were not in repair. I am credibly informed that when they were in repair boats were not allowed to pass backward and forward, but if they entered the canal were compelled to remain in it, because, as I was informed, they often injured the plastering on the lock walls.

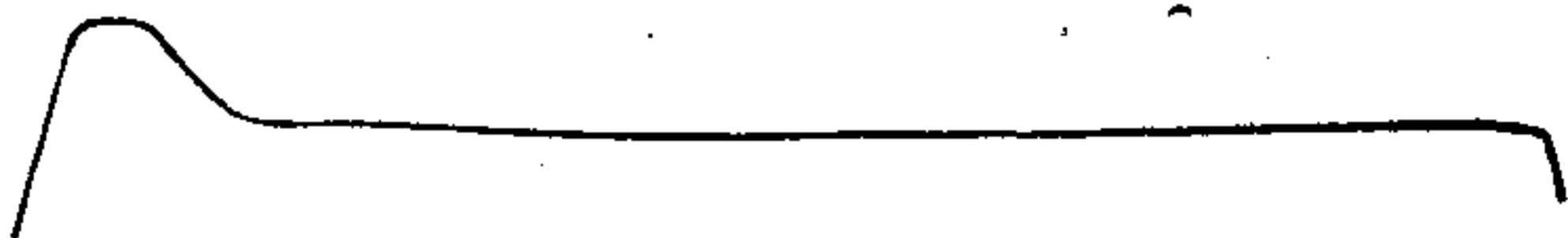
2nd. With respect to the second fundamental mistake, viz., the cutting the canal so as to carry the whole body of the water below the surface of the ground, this was entirely owing to the medical officer appointed to investigate the subject of fever, which, under certain circumstances, had appeared in irrigated tracts, going out of his depth in attempting to instruct the engineers how they were to execute the works. He had concluded that the fever was caused by the presence of the stagnant water, and he supposed that if the water was carried above the level of the ground it would percolate through the embankments, and keep the ground outside saturated. Not being an engineer, he did not know that the water would not find its way through the embankments in any quantity, nor that in that part of the country the upper three or four feet is generally of watertight soil, below which is the most open sand, through which the water passes quite freely. Hence in insisting upon the water being carried below the surface, he took effectual means to produce the very evil he wished to prevent. Had he merely insisted upon it, that there should be no land saturated with stagnant water, the engineers would have known how to accomplish that. But further ; the very object of the canal was to irrigate the land without the necessity of raising the water by artificial means. To do this and yet have the surface of the water below the level of the ground was evidently an absolute contradiction. And hence the water is, of course, now led out of the main canal by the branch channels, so cut as to bring the water out above the ground, and thus the water is only below the surface in the main canals, while it is above it in the branches. The real remedy against stagnant water is simply a system of drains leading it off to lower levels ; and this is essential to

having been cut so deep, the water is let through into the sand below, and the whole country is permeated by it, so that the water everywhere stands some feet higher in the wells than it need to do, and the people are tempted to raise it by bullocks from them instead of purchasing it from the canal.

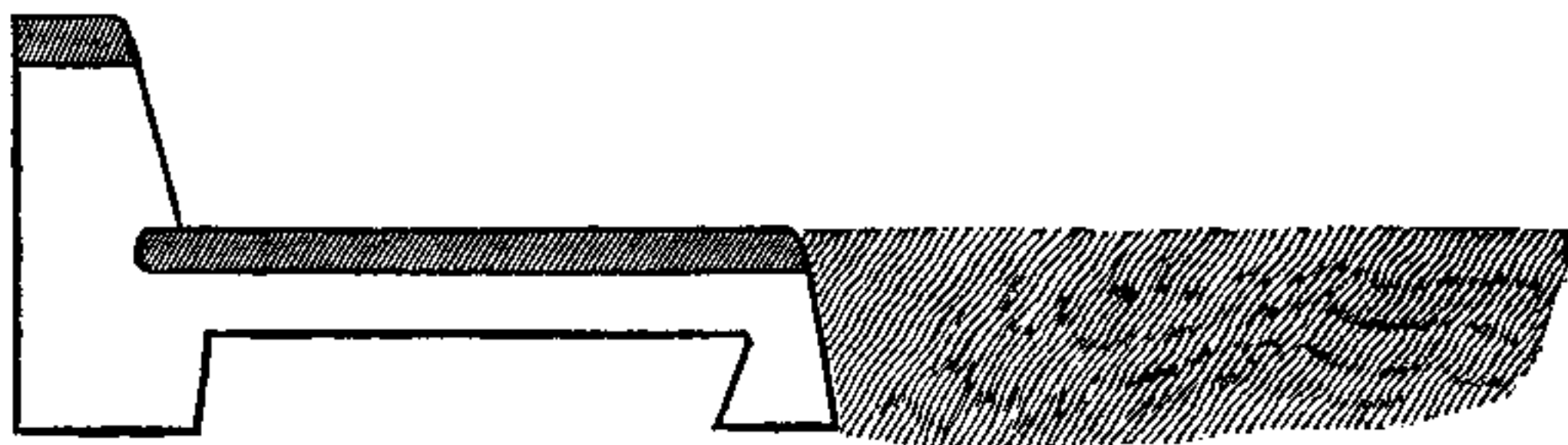
In thus following these instructions instead of determinately protesting against them, they have been led into a monstrous expense and loss of time. The excavation is certainly three times what it need to have been, being about 4 yards by 50, whereas an excavation of one yard or a little more, just sufficient to form the embankments, was all that was required, and as the embankments could have been placed at any distance apart, without increasing the quantity of earth required to form them, a body of water much greater than is at present conveyed might have been provided for at one-third of the present cost. Thus, supposing the embankments required a section of 60 square yards, each to allow of a depth of water of 3 yards above the ground, and they had been placed 200 yards apart, the excavation would have been 120 square yards, and it would have provided for a stream $200 \times 3\frac{1}{2}$ yards, or 700 square yards, while the present excavation is about 4×50 , or 200 square yards, and the stream of water $50 \times 3\frac{1}{2}$, or 170 square yards in the former, and the stream would have had a section of six times that of the excavation; while, as it is, the section of excavation exceeds that of the water. However, a far greater use may be made of the present excavation than has been made hitherto, by simply allowing the water to stand in it above the level of the ground. I have said that it was intended to allow 10 feet to flow down the canal, but hitherto only 7 feet has been admitted, in consequence of the works not being able to bear it with the present great slope of the bed, and the weak brick weirs. But the water might be allowed to stand at least 2 yards over the surface, or six yards deep, giving a section of water of about 60 yards by 6, or 360 square yards, instead of 50 by $2\frac{1}{3}$, or 117, as at present; and if the current, by diminishing the slope of the bed, is lowered from $2\frac{3}{4}$ miles, as at present, to $1\frac{3}{4}$, just double the present quantity of water would be conveyed. The alterations that would be necessary for this, viz., the addition of some weirs, in order to diminish the slope, are absolutely necessary to make the navigation effective. In this way alone, without any additional excavation, the canal may be made to irrigate twice what it is calculated to do, while only 7 feet of water are admitted.

Other means will hereafter be mentioned by which a far greater extent of irrigation may be obtained without any additional excavation of the main canals.

structing the works entirely of brick. There is nothing more inexplicable than this in the whole matter. I cannot find a word of discussion on this point in the published reports on the project. I had always supposed that the only great objection to it was the want of stone; and I was astonished beyond measure to find the most unexceptional stone lying in the streets of Hurdwar, which I was informed had been brought up 6 miles, and many of the houses built of stone. What could have been the reason of rejecting this invaluable material, the very thing that was wanted for the works, I am still totally at a loss to conceive. In Madras we never think of trusting to brick for hydraulic works, however hard and expensive to cut the stone obtainable may be, nor however far we may have to bring it; and, in my opinion, nothing but the absolute impossibility of obtaining it within a practicable expense would justify an engineer in building weirs and sluices without it. The present case is the strongest confirmation of this opinion. Nearly three times the quantity of masonry has been used in these weirs that would have been required had they been covered with stone, and yet they are now in a dangerous state, quite unequal to the force of water they are exposed to. The form of section is of this kind:—



Had they been covered with stone, the section should have been thus:—



In the locks, also, all the passages are of brick only; they ought all to be lined with stone most carefully fitted. The side walls also being of brick, the most peremptory orders are given that they are not to be scratched by the boats, and monstrous fines are inflicted for any injury to the plastering. Of course this is wholly incompatible with free navigation. The works ought to be so constructed as to bear the test of usage to which such works are exposed. I found sandstone of

various degrees of hardness; the soft would probably do for the parts of works not exposed to the rush of water, or to the chafing of boats and vessels; and the harder for the latter parts. I saw some of just the requisite degree of hardness; quite sufficiently hard to resist water, and at the same time not needlessly hard so as to involve an unnecessary expense in cutting. In Madras we have been often obliged to use excessively hard granite, at a very great cost, where much softer stone would have answered the purpose. Besides the stone to be obtained from the hills, the bed of the river is entirely filled with good-sized pebbles, which might be extensively used for rubble masonry, and for protecting the sides and bed of the canal, where wanted. Among these pebbles are also plenty which are of hydraulic limestone, so that I should report of this spot that scarcely any place could be found where hydraulic works could be constructed so securely and so economically. I may mention that the brick masonry in these works is of the very best quality; both materials and workmanship are as fine as any I ever saw, and from the published accounts of cost, it is evident that they have been most economically executed. The mistakes are in the projection, and the use of brick where stone was on the very spot, and of the precise quality required.

If quarries are now opened in the sub-Himalayas, there would doubtless be in a short time a prodigious traffic in stone along the whole line of the canal.

Many of these minor mistakes have further greatly increased the cost of the works; some of them are the causes of the present dangerous state of some of the weirs and bridges, and some of them almost destroy the canal as a line of navigation, so that the traffic on it in goods is now only $\frac{1}{50}$ of what it ought to be, and it is hardly used for passengers at all, whereas if the navigation were effective, steamers of all speeds would be carrying passengers to the extent of several thousands a day; probably starting from either end of the canal every two or three hours, and plying night and day. From the mere mention of these defects of projection, it cannot but be understood how it is that this work, in a tract of country with such prodigious natural advantages, has been so unproductive for seventeen years from its commencement, independently of the question of the distributive channels not having been yet completed.

↳ The money that has been expended is probably three or four times what would have been sufficient both for the irrigation of two millions of acres, and to have formed the most effective line of navigation in the world, with a prodigious traffic both in goods and passengers at any

I purpose now to enter more fully into the subjects of the different mistakes I have adverted to.

1st. As to the position of the head of the canal. In the reports I have seen there is no discussion at all on this point. In a paper of Colonel Baird Smith on the late famine, he justly remarks that the channel of the river below the steep country near Hurdwar, is too deep for head-works for a canal.

In the first place, as the head of the canal from Hurdwar to Roorkee, 20 miles, which has so great a fall, and crosses all the heavy drainage of the sub-Himalayas, has cost about $\frac{3}{4}$ of a million sterling, it is impossible that it could have been more expensive than that to have thrown a weir across the Ganges below the confluence of the Solani, and cut the head of the canal from there. But further I was informed by an officer of the canal department, that he had taken the level from the Futtighur branch of the canal, to the neighbouring bed of the Ganges in two places, and found it 40 feet in each, while the fall of the country there is about 3 feet a mile. Hence if the water of the river were raised 10 feet by a weir, and the head of the canal cut from it with a fall of half a foot a mile, gaining $2\frac{1}{2}$ feet a mile upon the slope of the country, it would only require a cut of 12 miles in length to lead the water out upon the present level of the canal, which could not possibly be an expensive work; it could not certainly cost more than $\frac{1}{10}$ of that of the present head of the canal above that point, while including also the permanent weir which the present head of the channel has not.

The objections to this position for the weir (probably a little below the confluence of the Solani) would be, first, that it would be further from the quarries, but as no stone has been used in the present works, this does not affect the question so far as these works are concerned. The stone would certainly have had to be brought some considerable distance, but this, though it would have increased the expense, would not by any means have done so to the extent of the least making it a question whether the weir could be built there or not. But now as the stone could be brought from Hurdwar by the present canal, with 3 or 4 miles of addition, to the very spot, the cost of carriage would be of very small account. 2nd. The country above the point where the new head would meet the present canal, would be above the level of the water, and consequently could not be irrigated from this work. This is not of the least consequence; there are many millions of acres below the level of that point which are not irrigated, nor intended to be irrigated by the present works, and it cannot therefore be a matter of the least consequence that a few hundred acres above that level are not irrigated. There is no reason whatever for irrigating that particular

little patch of country about Roorkee, rather than the vast area of the Doab lower down—and further, of course, now, that tract may continue to be watered by the present canal. The fall between Hurdwar and Roorkee is about 60 feet, and is of no use whatever, so that going up to that point was only bringing into the canal a height of 60 feet, which had to be counteracted by weirs and falls at a great expense, without any object whatever, besides entailing the enormous cost of passing the Solani, and the other violent jungle streams which bring down enormous floods for a few hours at a time.

It must be observed that the weirs on this part of the canal above Roorkee are in great danger. Last year one of them was repaired, but was again injured, and it was necessary in consequence to close the head of the canal, and put a stop to all irrigation for four months in the main irrigating season, entirely losing the whole revenue for the rubble or winter crop. The receipts for the previous year had been 6 lacs, and in consequence of the extended distribution those for 1862–3 would have been, I believe, almost 10 lacs, whereas they will be, I suppose, less than those of last year. But the loss of property in the crop would have been enormous, perhaps 30 rupees an acre on 500,000 acres, or 150 lacs, besides the loss of seed and labour, had there not occurred most providentially a very unusual fall of rain, which gave even above an average crop. This mischief was solely owing to the weir being built of brick, which can never be trusted for hydraulic works with falls of water or high velocities. Had they been properly constructed works covered with stone, there would have been no such danger. It must be known also that this danger has occurred with only 7 feet of water in the canal, whereas the works were calculated to bear 10 feet of water, which has not yet been admitted. The quantity of water calculated upon was about 8,000 cubic feet per second, one million cubic yards per hour, while the quantity actually admitted is only about 5,000 cubic feet per second, or 620,000 cubic yards per hour. And of this, in consequence of the want of distribution works, only one-fourth has ever been used, even during the famine, the remainder returning unused into the river.

This great mistake of beginning the canals needlessly high up the river was very nearly made in the case of the Godavery. It was at first thought that they should commence at the point where the river escapes from the hills, but upon levelling the country it was found that nothing would be gained by this but the having to convey $1\frac{1}{2}$ millions of cubic yards of water 25 miles for nothing—the gain of level by going 25 miles higher up giving no advantage worth mentioning; while it was wished to water the small additional tract

incurring the enormous expense of carrying $1\frac{1}{2}$ millions of cubic yards all that additional distance. This change in the position of the head of the channel would have saved 70 (?) lacs, and of course several years, besides all the loss and danger now experienced in the actual state of their head works at this moment, which is such that, unless decisive measures are immediately adopted, the canal will continue useless, and the prejudice against irrigation works be prodigiously increased.

It is certain that something must be done about these works; first, those now in danger must be secured, and, secondly, the supply of water to the canal must be secured by a permanent weir. In the face of the famine, the temporary dam across the river had been constructed after the monsoon as usual. When the river began to rise in the following monsoon, this dam was as usual, carried away. But in consequence of the failure of the rains, the river did not continue to rise as it ought, and, consequently, at the very time when the canal water was most urgently called for, the proper supply could not be thrown into it, as there was not enough water in the river to keep that in the canal at the required level, but at the same time there was too much to allow of the temporary dam being restored. Thus a work which has cost $2\frac{1}{4}$ millions is liable to be left without a sufficient supply of water at the time of a failure of a monsoon, when the general need for the canal water occurs to prevent a famine, for want of a permanent weir that would cost 30,000*l.* or 40,000*l.* The canal, even with this insufficient supply of water, is of course still of incalculable value, though of nothing like what it ought to be. In the late famine it watered about 300,000 (?) acres, and *produced* food for $1\frac{1}{2}$ millions of people for a year, according to Colonel Baird Smith, besides being the means of conveying vast quantities of food from distant districts, neither of which would have been otherwise obtained, and as many thousands died of starvation as it was, probably hundreds of thousands would have perished but for the canal, thus imperfectly supplied with water from the head, and only about one-fourth of that water being actually used for want of the distributing channels to convey it to the lands. Its use also for bringing food from a distance was only a small part of what it ought to have been, had the defects of the navigation not existed, and had it extended to the confluence of the Jumna, at Allahabad, instead of stopping short at Cawnpoor.

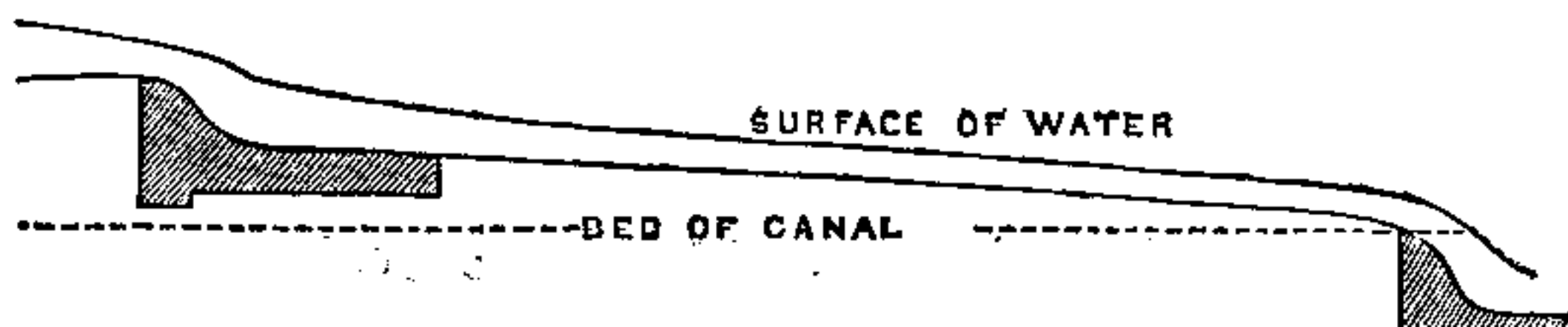
But to return to the question of the head works, which is, what should now be done there? I have stated that the present weirs cannot stand the force of water to which they are exposed, even with only 7 feet in the canal instead of 10 feet, the full supply; also that a

the admission of the whole supply of water, it seems to me that the only thing that can be done to meet the emergency is to build new weirs on side cuts out of the line of the canal opposite to the present weirs, so that they may be completed without shutting the water out of the canal, and when completed the banks at heads and outlets of the new cuts may be cut through, and earthen banks thrown across the main canal so as to shut off the water from the present weirs. The new weirs, of course, to be constructed of stone.

But if the new permanent weir across the *river* is constructed, not at the present head, but below the confluence of the Solani, so as to admit the main supply from the river at that point, only a small quantity might be admitted at the present head, so as to allow of only 2 or 3 feet flowing down that part, and so relieve the present insecure weirs; and this they would probably be able to bear, with the help of some trifling alterations. The object of admitting any water at all at the old head would be merely to keep up the navigation there, and to supply the small tract now watered above the level of the proposed new head. The traffic at this extreme part of the canal will, of course, not be very great, so far as general trade is concerned, but as affording the means of conveying the excellent stone of Hurdwar, and the timber of the Himalayan forests, both to the works all along the canal, and for the use of the public all the way to Allahabad, this part of the navigation will be of great importance.

If the depth of water is reduced from 7 to 3 feet, the current will be diminished from $2\frac{1}{2}$ to $1\frac{3}{4}$, which the bed and banks will bear, and the force of the water over the weirs will be greatly diminished.

It is necessary here, however, to point out another fact with respect to these weirs across the canal. I have stated that the length of them is the same as the full breadth of the canal, and consequently the depth of water passing over their crest is less than that of the canal at a distance above the weirs. It is obvious that the velocity of the water over the weirs will be much greater than that in the canal, and consequently a depth, for instance, of 7 feet in the canal would not keep up a depth of, suppose, 3 feet over the weirs. Now, the bed of the canal is made with a slope of $1\frac{1}{4}$ feet a mile from the foot of the weir to the top of the next, so that the surface of the water will have an additional fall of 4 feet in the area given, more than the bed, thus,



so that, while the canal has nominally a slope of only $1\frac{1}{4}$ feet a mile, giving a current of $2\frac{1}{2}$ miles, the last mile or two above a weir has a slope of the surface of the water of perhaps 3 feet a mile, giving a current of four or five miles an hour; far above what was intended, and above what the bed and the banks can bear. The fact is, the weirs ought to have been made so much shorter than the breadth of the canal as to have kept the depth over their crest the same as that in the canal, so that the slope of the surface of the water would be the same as that of the head of the canal, and the current would then have been kept at $2\frac{1}{2}$ miles an hour, as intended. The current above the weir has thus been so excessive that the sides of the canal were cut away to a dangerous extent, and to remedy it, the desperate measure has been resorted to of raising, by timber work, the height of the weirs, and thus exposing those weak structures of brick to a force of water now much beyond what they were intended to bear.

It seems, therefore, almost certain that, by making a new head to the canal below the confluence of the Solani, far less expense will be incurred than by correcting the works on the canal above Roorkee. If these works, with the help of slight alterations, will have a depth of water in the canal of 3 feet, instead of 7, as at present; the cost of cutting 12 or 15 miles to form a new head will be less than the substitution of stone weirs for the present brick ones. The weirs across the Ganges will, of course, be nearly the same, whether built at Hurdwar or below the Solani.

4th. With respect to the fourth mistake, viz., that the water is all admitted at the head of the canal, so that some of it is conveyed 350 miles to the lands it waters at a monstrous cost:—Supposing the land in the centre of the Delta is 50 feet above the bed of the river nearest to it, and that the fall of the country is $1\frac{1}{2}$ feet a mile in a certain part (the actual fall is about 3 feet a mile near Roorkee, diminishing to about a foot at Allahabad), it is evident that, if the water is first raised 15 feet by a weir across the river, and then carried by a canal with a fall of $\frac{1}{4}$ foot a mile, gaining $1\frac{1}{4}$ feet per mile upon the river, such a canal would only be carried 28 miles before it would have attained to the level of the land in the centre of the Doab, where it would command the whole tract, and might afterwards be carried along the water-shed, thus,—

	Feet.
Total difference of level between river and land	50
Height gained by weir	15
	—
	35

Height gained by canal having a less slope than the

In this case, therefore, instead of bringing the water, suppose 250 miles from Hurdwar to 100 miles above Cawnpoor, it would only have been conveyed 28 miles, and there would have been a saving of 225 miles of canal against the construction of a weir. The cost of the latter might be 5 lacs, and that of an excavation of, suppose, 50 square yards of section, say at $1\frac{1}{2}$ annas per cubic yard, or 9,000 rupees a mile, would be, for 225 miles, 20 lacs; but the difference of cost would only be a part of the advantage; it would provide for a large additional supply of water beyond what could be obtained from the present head, for it would secure the water draining out of the sands of the river in those 225 miles; besides, any flowing into it from the small affluents that enter the river in that space. The same might be done with the Jumna, and thus at a small cost 3 or 4 times the land might be irrigated that is at present provided for. Probably one or two such additional heads from each of the rivers Ganges and Jumna might be cut with advantage. It is to be observed that the whole area of the Doab, all available for irrigation, is about 10 million acres, of which, say, about half a million acres have yet been supplied, and the present arrangements would only provide for $1\frac{1}{2}$ million acres, even if the full supply of 10 feet depth were admitted into the canal, while the two rivers would probably supply 4 or 5 million acres, even when at their lowest, and of course the canals should be cut so as to allow of a much greater quantity than the lowest supply being conveyed by them.

There remains also the storing of water to be considered. The information I obtained as to sites for large tanks at the foot of the Himalayas was not very favourable; but still I have no doubt that large quantities of water could be stored there at a practicable cost, though not so cheaply as in most parts of India.

5th. I have already spoken of the necessity for a permanent weir at the head of the canal, and of the unaccountable mistake of leaving a work that has cost $2\frac{1}{4}$ millions imperfectly and uncertainly supplied with water, for want of an expenditure of 30,000*l.* or 40,000*l.* There seems to be now something like a real impression that such a work must now be executed, but it is still put off, apparently under the strangest fancy that such a work is one of most serious difficulty, though it is nothing to the works of the kind that have been executed in Madras in many places, both by natives and Europeans. The quantity of water to be discharged over it in extreme floods is about 25 million cubic yards per hour, while the quantity which has to be provided for in the Godavery is 200 millions, and in the Kistnah about 160 millions, and both these works have been executed without any serious difficulty. The officers at the head of the P. W. D. of India seem to be afraid of the work, though it is only a weir, and is of a

In the meantime, what with the uncertainty of the supply, and the dangerous state of some of the weirs and other works, this most important work is in the most imminent danger of becoming a failure, and a terrible obstacle to similar works. One season has been already entirely lost from the necessity of shutting the water out of the canal, and it can only be kept open this year with very great anxiety lest some of the weirs should fail entirely. Not a moment should be lost in taking the works in hand with decision that are necessary to put the project in a safe and effective state.

With respect to the minor mistakes I have mentioned:—1st. The weirs across the canal being made of a length corresponding to the breadth of the canal, I have already shown the evils arising from this; besides that they have cost more than double what they would have done, had they been made of the proper length.

2nd. The placing the weirs in the direct line of the canal, and cutting channels with locks in them on one side of the main canal for the navigation. There is no reason for this; the navigation was the thing to be cared for; it was a matter of no consequence that the water should be led round by a circuitous course. The boats now have to get out of the current which leads direct to the weirs, and to turn into the side channel, and of course not without danger. Some boats have thus been carried over the falls, and several lives have been lost. This should now be corrected, at least below Roorkee, by making new weirs out of the line of the canal; the present dangerous state of the weirs at any rate makes this imperative, and it is only by building them out of the main line that the canal can be kept in use while they are under construction.

3rd. The great fall in the bed of the canal, $1\frac{1}{4}$ to 1 foot per mile, which, with a depth of 10 feet, would give a current of $2\frac{3}{4}$ or 3 miles an hour, which is too much both for the bed and sides of the canal, and for the navigation. The sides of the canal have in several places been cut by the current, and the bed, especially at the bridges, dangerously deepened. It is absolutely necessary to diminish the slope by building additional weirs; and as there is nothing to prevent a much greater depth than 10 feet being admitted into the canal, and it is clear waste to admit into it less than it can carry, the slope should be reduced to a very moderate rate. If 18 feet of water is admitted, which I believe the banks will abundantly allow of in a great part of the length, the slope should not exceed 3 inches per mile, which would give a current of about $1\frac{3}{4}$ miles, or 3,000 yards per hour, and I think more than this cannot be allowed with safety to the sides, and without serious inconvenience to the traffic. In fact I am of opinion that that current is the outside of what can be allowed, so as to make the navi-

There remains the question of entirely correcting the level of the bed by cutting and fitting in from weir to weir. This is not, perhaps, absolutely necessary, but it would not be very expensive. For instance, suppose in the lower part, where the slope of the country and of the bed is about 1 foot, and it would have to be reduced by 9 inches, it would require that weirs 12 feet high should be placed at every 16 miles, or if, as there would be less depth of water in this part, a slope of 6 inches were allowed, they would be required at every 24 miles.

It seems certain that the greater traffic will be down stream, and in such a case there is a decided advantage in having a certain current. In the upper part, at all events, the main traffic will be down; it will consist there chiefly of timber, firewood, and stone; the grain and other produce will of course increase from the upper to the lower end, and at the latter it will certainly be enormous. The up-traffic will indeed be very great at the lower end, in salt, coal, and rice, and this will diminish towards the upper end. The other traffic will of course be small compared with these items. The passenger traffic will be equal up and down, but of course regularly increasing towards the lower end. It must, however, be remembered, that when this navigation is connected with lateral lines, as in Oude, &c., many more and unexpected items of transit will be brought upon the line which cannot now be estimated. As the passenger traffic will probably be chiefly by steam, with speeds of 5 miles and upwards, the current will not so much affect that. I am inclined to think that it will be well to give one side of these canals a very long slope, 3 or 4 to 1, which will allow of the up-traffic getting almost entirely out of the current. Thus a boat drawing 4 feet would be in a current of only half of that of the centre of the stream, or about three-quarters of a mile per hour. The additional expense of this would not be very great, and I think it would be a great benefit to the navigation.

Of course, if a great depth of water is allowed in the canal, there must be a proportionately reduced slope of the bed, the depth of water and the fall per mile equally affecting the current; that is, a depth of 18 feet, with a fall per mile of $\frac{1}{4}$ foot, and a depth of 9 feet with a fall of $\frac{1}{2}$ foot, would each give a current of about 3,000 yards, or $1\frac{3}{4}$ miles in the middle. The object in proposing so great a depth as the former is merely to take advantage of the enormous excavation which has been made; it would certainly entail a greater number of weirs in reducing the slope of $\frac{1}{4}$ foot, the cost of which (and the more frequent interruptions from locks) must be set against the gain of additional water. Had the original mistake not have been committed, of course the proper plan would have been to make the embankments further apart, and then to have a less depth of water. Probably 6 feet would be a more suitable depth than either of the

that a slope of $\frac{3}{4}$ foot might have been allowed, which would have made a difference, compared with $\frac{1}{4}$ foot, of 240 feet between Hurdwar and Allahabad (480 miles at $\frac{1}{2}$ foot), or of 24 locks, with 10 feet lift, one less in every 20 miles.

4th. The termination of the canal at Cawnpoor, instead of its being carried on 120 miles to Allahabad. This is a most serious mistake as respects the navigation, even if the irrigation were not carried below the first place. There is not one single obstacle of the smallest kind along this whole line; the rails are laid throughout almost on the surface of the ground, and very nearly in a straight line. The excavation, therefore, for a canal would be of the most insignificant kind. If it were made on a dead level, the fall being about a foot a mile, there would be 10 locks of 12 feet lift each, or one every 12 miles; the least excavation for a canal 40 yards broad, and 9 feet deep, would be about 60 square yards, to make two embankments $2\frac{1}{2}$ yards high, the excavation being $1\frac{1}{2}$ feet deep, and the greatest excavation would be just below a lock 40×5 , or 200 square yards, and the average about 140 square yards, which at $1\frac{1}{2}$ annas per cubic yard, would give 24,000 rupees per mile, besides locks and bridges; the former would cost about 30,000 rupees each, or 2,500 rupees a mile. But the cost might be greatly reduced by making the locks more frequent, with a smaller lift, as the excavation would then be greatly reduced, and it must be remembered that the interruption from locks is very insignificant, if they are made with ample water passages so as to fill or empty in one minute. If the locks had a lift of only 6 feet instead of 12, the greatest excavation would be only 160 square yards and the average about 110, or the cost 18,000 rupees a mile. This provides for a very large canal 40 yards broad, and also supposes that no irrigation is provided for. But it would, no doubt, be better to irrigate from this part of the canal, as the giving the water a current would not increase the cost. Small weirs would be required, but fewer locks.

With this continuation of the canal, thus conveying the traffic into the Ganges at the confluence of the Jumna, the value of the upper canal for navigation would be prodigiously increased, and the returns from tolls accordingly. If the extension cost 25,000 rupees a mile in all, a net toll of $\frac{1}{2}$ pice per ton, and per head, would require a traffic of half a million tons, and half a million passengers, to give a return of 10 per cent. on navigation alone, and I feel confident that the traffic would soon equal that. If the Soane or the Oude projects are carried out, of course this line would be connected with them by aqueducts across the Ganges and Jumna, and a vast impulse would thus be given to the traffic on the Ganges canal.

5th. The continuation of the slope of the canal quite to the end at Cawnpoor. The consequence of this has been a continual cry that water could not be spared for navigation. No water is required for navigation, excepting for lockage, which is insignificant, and for evaporation, which on a canal 40 yards broad is about an average of 2 cubic yards per hour per mile, a matter of no consequence. The only thing that is required in combining navigation with irrigation is to reduce the line of the canal, below where the irrigation ceases, to levels by locks. If the last 30 or 40 miles above Cawnpoor had been thus reduced to levels by three or four locks, no flowing water would have been required.

6th. The low bridges. Only 7 or 8 feet of headway had been allowed, a most serious obstacle to navigation, especially to steamers. The remedy for this is to cut side channels at all the present bridges with higher arches, or rather, perhaps, with girders. About 10,000 rs. each would probably provide for girder bridges with a span of 45 feet, allowing of two boats passing each other under them, with the excavation. The channels should lead off from the present canal at extremely easy slopes, so as to offer no inconvenience to the navigation, supposing there are 120 bridges on the canal. This correction would cost about 12 lacs. It would not interrupt the use of the canal, and with girders the whole could be done in a few months. This is absolutely necessary. The present state of the bridges is almost destructive of navigation, especially of steamer-passenger traffic.

7th. The towing-paths not being carried under the bridges. This will be corrected by the side bridges above proposed.

8th. The sharp curves in the lock channels. This must be corrected in the present lock channels by lengthening them, which can be done at no great expense. When additional weirs are constructed, as they will be placed out of the line of the main canal, the new locks should be placed close to the side of the latter, so that they may be built without closing the canal, but with a very slight deviation from the straight line of the canal.

9th. The disposal of the silt. I think this should be expressly provided for in all such works in future. If water flowing at 5 or 6 miles an hour be admitted into a canal, and its current reduced to 2 or 3, the greater part of the suspended silt is of course rapidly deposited, and most of this is simply barren sand, which is very injurious to the land.

10th. The want of cross lines of navigation to connect the different branches of the canal. This is a great defect, and it can be remedied at a small cost. The whole breadth of the Doab is small, and level lines could be selected to lead from one branch to another without any

difficulty. It is evident that if to get from one side of the Doab to another—suppose 40 miles—they have to go 250 miles up one branch, and 200 down another, it is a most unnecessary evil. A few cross lines can be cut for a trifle so as completely to remedy this.

11th. The Solani aqueduct.—This cannot now be corrected, as the money has been spent, but the consideration of the subject is of great importance in its bearing on the cost of irrigation works. The dimensions of the earthen canal were decided upon the basis of the current that earth could bear; it was allowed in this case to be 3 miles an hour. ✓The dimensions of the masonry aqueduct were then made exactly the same. Why? In passing water through masonry we are not restricted to 3 miles an hour. The water passes through the lock passages at, perhaps, 10 or 15 miles an hour, or more. It is evident that the water might have been sent through the aqueduct at three or four times the rate that it passes along the earthen canal; and hence that a work of one-third or one-fourth the width of the canal would have been sufficient. In Tanjore we never think of making masonry aqueducts of the same dimensions as the channels that lead to them. The Solani aqueduct is 250 yards long, so that a fall through it of $1\frac{3}{4}$ feet, equal to 12 feet a mile, would have given a velocity of 9 miles an hour, or three times that of the canal; and have consequently reduced the breadth of the work to one-third, and consequently the cost to little more than one-third: a saving of, I believe, 9 lacs. The navigation, of course, is small at this extreme point of the canal, but it might have been provided for, either by heaving the boats through by means of cranes worked by men or cattle, as is done in the rapids of the Wye, and other rivers in England, or by making a separate chamber of the breadth of the locks, 16 feet, with gates to it. Even with this latter arrangement, the breadth of the aqueduct need not have been above 25 yards instead of 66; but probably the first plan would have answered the purpose, making it 6 yards narrower. In this way about 100,000*l.* might have been saved in this work. Again, in the same way, the water of the stream which it crosses, passes through it at a moderate velocity. But it would have been much cheaper to have strengthened it by an apron, &c., so as to have allowed of the water passing through it at, perhaps, double that velocity. In the Gunnarum aqueduct in the Godaveri delta, the water of the river rises 5 feet over the crowns of the arches, and is discharged through it at a great velocity, the bed of the river being secured by rubble masonry and loose stone. In this way the Solani aqueduct might have been made, perhaps, half the length it is, which, combined with one-third of the breadth, would have reduced the cost to about one-fifth of what it was, or 3 lacs instead of 6.75.

proportionately reduced the time of construction. Now, whether an irrigation work is executed for 15 lacs or 3, and whether it takes 1 year or 5 years to construct, make the difference of whether it yields 25 per cent. from the first year, or 5 per cent. after 5 years. It is evident that upon such things as these depends whether such works are an immense success or a partial or a complete failure.

In building a bridge, an aqueduct, or a weir, the simple question is, how can a certain quantity of water be passed through or over at the least cost, viz., whether by a work with of suppose a certain length, or a stronger one of suppose half that length. This is the point. Now in the case of the Kistna Anicut, we have proof that we can discharge an enormous quantity of water over a short weir, about 200 million cubic yards per hour over one of 1,100 yards, or 180,000 cubic yards per yard of length, and in the Gunnarum aqueduct we have a proof at how high a velocity water may be discharged through a bridge or aqueduct with safety.

12th. The narrowness of the canal near Cawnpoor.—This is out of all proportion to the traffic that there would be if the navigation were in an effective state. I am inclined to think that none of the main canals situated like this, in the heart of the valley of the Ganges, ought to be less than 30 yards in breadth, to allow of the free passage of fast steamers, and very numerous cargo boats. They might, of course, be narrower as the distance from Calcutta increased. It would, perhaps, not be necessary to increase the breadth of this part of the canal by excavation, but merely by raising the locks and weirs so as to fill the present excavation to a greater depth, as the water at present stands many feet below the top of the embankments.

13th. The steepness of the slopes of the sides of the canal.—This can be easily corrected. If the canal is filled much above its present level, the earth might be merely thrown down into the channel, but even if it had to be carried over to the back of the embankments, it would not be very expensive. At present there is a continual cry against a ripple on the banks, and a senseless denunciation of steamers on a canal; if a canal is not made to bear this kind of thing, it is utterly inefficient. An effective navigation, whether for goods or passengers, ought of course to be quite able to bear a ripple on the banks. For this the banks should have a good slope, and if necessary for a yard above and a yard below the surface of the water; the slope should be covered with loose stones, which can be done at a trifling cost. Suppose, for instance, 2 yards' breadth on each side, with a thickness of 1 foot, this would require 2,400 cubic yards, or 3,000 tons per mile, which might cost on the Ganges canal, if carried on an average 200 miles, 3,000 rupees a mile; but I do not think this would be neces-

sary unless the banks were of mere sand. In a canal of 30 yards broad and upwards, it is evident that it would be a matter of very little consequence if the slope of the sides near the water's edge were reduced to a slope of 5 or 6 to 1 by the ripple. It is only in the small canals in England, where there is not a foot to spare, and which were not made to bear the slightest ripple, that this is a serious matter.

14th. Incredible as it may appear, after constructing pairs of locks to connect the canal with the river at Cawnpoor, as if to provide for a vast traffic, the actual passage of boats from one to the other has been systematically obstructed, first by forbidding it, then by heavy fines for slight injury to the plastering, and lately by allowing the lock gates to get out of repair, so that the boats could not pass through. From first to last, there seems to have been the strangest misapprehension of the importance of the line of navigation, notwithstanding that a great expense has been incurred in locks. Lord Ellenborough indeed wrote a minute dwelling upon the importance of the navigation, but I have never been able to obtain a sight of it; it was written about *his time of signing*. Of course every possible facility should be given for boats going from the canal into the river, or the contrary. Their not being allowed to do so, probably at once stops $\frac{5}{6}$ of the traffic. How so great an absurdity as the allowing the slightest obstacle to this to remain could have been permitted, is inexplicable.*

* I have spoken of the flowing of streams to the sea, as a partial image of the action of wealth. The popular economist thinks himself wise in having discovered that wealth, or the forms of property in general, must go where they are required; that where demand is, supply must follow. He further declares that this course of demand and supply cannot be forbidden by human laws. Precisely in the same sense, and with the same certainty, the waters of the world go where they are required—where the land falls the water flows. The course neither of clouds nor rivers can be forbidden by human will. But the disposition and administration of them can be altered by human forethought. Whether the stream shall be a curse or a blessing depends upon man's labour and administering intelligence. For centuries after centuries, great districts of the world, rich in soil, and favoured in climate, have lain desert under the ∇ rage of their own rivers, not only desert but plague-struck. The stream which, rightly directed, would have flowed in soft irrigation from field to field, would have purified the air, given food to man and beast, and carried their burdens for them on its bosom, now overwhelms the plain, and poisons the wind—its breath pestilence, and its work famine. In like manner the wealth goes "where it is required;" no human laws can withstand its flow. They can only guide it; but this the leading trench and guiding mound can do so thoroughly that it shall become water of life, the riches of the land of wisdom,† or, on the contrary, by leaving it to its own lawless flow, they may make it what has too often been, "the last and deadliest of national plagues, water of Marah, the water which feeds the roots of all evil."

† Length of days in her right hand, in her left riches and blood.

What I consider, therefore, is required to bring this most important work to completion, and to make it thoroughly effective, both for irrigation and navigation, as well as to obtain from it ample direct returns in money, is as follows:—

1st. To form a new head with a permanent weir below the confluence of the Solani, through which the main supply of the canal would be received, leaving only a small quantity to be admitted by the present head, just enough to keep up the navigation to Hurdwar, and no more than the present works in that part of its course will bear.

2nd. To make such small alterations to the weirs, &c. there, as may be necessary to make them quite secure under the moderate force to which they will then be exposed. Perhaps about 3 feet of water will be sufficient to allow to flow down that part of the canal, giving a current of about $1\frac{3}{4}$ miles.

3rd. To construct new weirs below the new head of stone, and out of the main line of the canal, instead of the present brick ones.

4th. To add such additional weirs with locks as shall reduce the bed to a slope of from one quarter to one-half foot per mile, so as to keep the current within $1\frac{3}{4}$ miles, and at the same time allow of the canal being filled as high as the banks will admit, so as to make full use of the present excavation.

5th. To increase the slopes of the banks so that they shall not be liable to injury from ripple, and at the same time allow of boats, when ascending, to keep in shallow water, and avoid the strength of the current.

6th. To form a large basin near the heads of the canal, through which the water will flow at not more than 1 mile an hour, for a mile or two, and thus deposit all its heavy silt, which may be removed by dredges constantly at work there without interrupting either irrigation or navigation.

7th. To construct new bridges of one span of about 40 feet, as a continuation of each of the present bridges, just out of the line of the present canal, of sufficient height to admit of free navigation, with a headway of 12 or 15 feet.

8th. To correct the present sharp curves in the lock channels.

9th. To put the connection with the river at Cawnpore in perfect order.

10th. To extend the canal to Allahabad, both for irrigation and navigation, both locking down into the river there also, and carrying it over the Jumna and Ganges by aqueducts to connect it with canals if constructed beyond those rivers.

11th. To form additional heads, with permanent weirs, both in the

additional water into the lower parts of the canal. The weir near the Solani will afford a larger supply than one in Hurdwar would in the lowest season, because additional water drains out of the sands in the intermediate bed of the river, and again a great additional supply will be obtained by weirs 200 or 300 miles lower down. But I would by no means restrict the supply in the canal to the lowest quantity in the river; there is plenty of time to secure a crop between the conclusion of the monsoon and the time of the lowest supply, which is in March, so that a much larger area may be watered than the lowest supply would provide for. The quantity as yet admitted has been only about 700,000 cubic yards per hour; the quantity in the river at the lowest below the Solani is more than a million, and probably half a million more may be admitted with advantage when there is so much in the river, and about a million more may be probably obtained from each of the lower weirs, making in all $4\frac{1}{2}$ millions, or six times as much as has yet been admitted, and about twenty-five times as much as has yet been used; and as 300,000 acres have been already irrigated, this would provide for $7\frac{1}{2}$ millions of acres, the total area of the Doab being 10 million acres, of which about _____ acres are already watered by the Eastern Jumna canal.

12th. The country at the foot of the Himalayas should be examined for sites for tanks, to provide _____ other additional supply of water in the cold season. From such information as I could obtain, I conclude that that tract is not very favourable for this purpose, but still I think it will be found that water can be stored there at a practicable expense. If an acre can be watered for one crop by 1,500 cubic yards of water, and the water rate for a single crop is 1 rupee, it is evident that water stored at a cost of 1 rupee for 300 cubic yards will yield a return of 20 per cent., as no other expenses will be incurred in making use of it, excepting a very little for the small branch channels of distribution, all the other channels being supposed to be made of a capacity to convey a larger body of water than the river supplies when at its lowest. The above cost would be 3,300 rupees per million cubic yards, whereas we estimate that in favourable sites water may be stored at 500 rupees per million, and lower, so that there is abundance of margin in the above cost, and this arrangement may be made for a vast extension of irrigation, and the canals ought to be made of great capacity to provide for the time when abundance of water may be stored.

13th. To cut cross lines of canal connecting the different branches at several points; and especially to cut lines which shall bring the traffic from the various parts of the Doab as direct as possible to all the great cities, Agra, Delhi, &c. The navigation of this tract will be very imperfect without these.

14th. To cut long canal basins, skirting the cities of Cawnpoor, Allahabad, &c., so as to allow of goods and passengers being landed opposite to all points of them, instead of having only one square basin which will oblige the goods, &c., to be carried a long way through the streets.

15th. To cut the distributing and drainage channels for the extended irrigation.

The following would then be a rough estimate of thus completing the project:—

	£
New head and weirs near the Solani	100,000
Correcting the present works above that point	20,000
New stone weirs on the canal below, instead of the present ones	5,000
Additional weirs and locks to diminish the slope of the canal to Cawnpoor.....	100,000
Sloping the banks of the whole canal, 700 miles at 300l.	210,000
Silt basins near the heads of the canal.....	5,000
New bridges with more headway; 150 at 8,000 rupees each	120,000
Correcting the present lock channels	5,000
Alterations at Cawnpoor	10,000
Extension to Allahabad; 120 miles ^{at} 25,000l. a mile	300,000
Additional heads, with weirs on the Ganges and Jumna, 200 or 300 miles below the Solani.....	200,000
Storing water for 2 million acres, at 1,000 cubic yards per acre; 2,000 million cubic yards at 200l.	400,000
200 miles of cross canals at 1,000l.....	200,000
Distributing and draining channels for 7 million acres at 1½ rupees an acre	1,050,000
Total cost.....	5,025,000
Or, per acre.....	15s.

Deduct already expended..... 2,300,000

Additional capital required 2,700,000

This would probably include, at least, 2,000 miles of first-class navigation.

GANGES CANAL.

A

VALEDICTORY NOTE

TO

MAJOR-GENERAL SIR ARTHUR COTTON,

RESPECTING,

THE GANGES CANAL,

WITH A POSTSCRIPT

TOUCHING CERTAIN MISREPRESENTATIONS OF A WRITER IN
THE "TIMES" ON THE SAME SUBJECT.

BY

COL. SIR PROBY T. CAUTLEY, K.C.B.

LONDON:

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1864.

A VALEDICTORY NOTE,

ETC., ETC. •

IN concluding my first reply to Sir Arthur Cotton's so-called private memorandum, I remarked that "here, as far as I am concerned, the matter drops," and I had hoped that with that one effusion of mine the controversy, so far as I was concerned, would end. When writing thus, I had forgotten that "the beginning of strife is as when one letteth out" (or letteth in) "water." The engineer who, on a recent occasion to which I need not more pointedly refer, allowed water to be let into an imperfectly finished canal, did not, of course, foresee the consequences in the destruction of the banks which his skill had constructed to restrain it; neither did I, when permitting myself to be dragged into this controversy, expect that it would carry me three times as far as I bargained for. But Sir Arthur Cotton's late pamphlet compels me to say a few valedictory words, which, though I call them by that name, will scarcely, I fear, exert a very pacifying influence. What I have to say will be confined to two points, which are involved in two pas-

sages in my last pamphlet, which Sir Arthur Cotton is pleased to characterize in no measured terms.*

The first is that where I quote the late Colonel Baird Smith's assertion that Sir Arthur Cotton's original estimates for the Coleroon works were, as subsequently avowed, made designedly lower than they ought to have been, with a view of inducing Government to commit itself to the works.

Upon this extract Sir Arthur Cotton truly remarks that it was taken from the middle of a long paragraph, wherein Colonel Smith expresses the highest admiration of his (Sir Arthur Cotton's) professional skill, and bears the strongest testimony to the efficiency of his engineering works. Sir Arthur Cotton then proceeds to pronounce Colonel Smith's assertion to be "~~an~~ abominable and unfounded personal charge," entirely of his own invention, evincing a strong bias on his part, which would have induced him, if he could only have found a pretext, to calumniate those very engineering works which he nevertheless did actually so liberally eulogize. Very aptly does Sir Arthur Cotton here observe parenthetically that "people do not lose their self-control till they feel they have lost their cause," and that

* Any further discussion on the Ganges Canal is useless. So far as I can understand, it has resolved itself into the following :—

1st. The expediency, financially speaking, of constructing dams on the Ganges and Jumna in their trough regions.

2nd. The practicability of combining navigation and irrigation in canals, whether in Madras or in the North-Western Provinces.

Sir Arthur Cotton and I are, on both these questions, diametrically opposed to each other. From further discussion between us nothing can be gained. Dams are not likely to be built in the trough regions of the North-West, and we, therefore, have little chance of practical experience on the subject; and although I have no doubt that the irrigation-cum-navigation problem will ultimately be found as difficult to solve in Madras as it has been in the North-Western Provinces, still to forestal its practical decision might here be out of place.

“it is only desperation and the want of weightier missiles that drives gentlemen to throw mere dirt.” Some such desperation it was, apparently, which drove Sir Arthur Cotton to declare it to be evident that to accuse an officer of falsehood without supporting the assertion by proof is wrong, and that for another to repeat it is in one degree worse. With all deference to so strict a precisian in morals, I would venture to suggest that what is really wrong, is rather to accuse a deceased brother officer of what is incapable of proof, as Sir Arthur Cotton does when he says “he is certain that Colonel Baird Smith never saw or heard made by any one else,” a statement which, Colonel Smith in no ambiguous terms assures us, did not originate with himself. No one who knew the late Colonel Baird Smith can doubt that, were he still living, he could readily point to his informant, and that it was only because he supposed himself to be speaking of a fact perfectly notorious, that he abstained from bringing his evidence forward. Now, however, Sir Arthur Cotton protests that the statement was simply a pure invention, and adds that I, for repeating it, am worse than the inventor. I might, perhaps, sufficiently excuse myself by pleading that it is eight years ago since the statement in question appeared in print, and that Sir Arthur Cotton, although he complacently swallowed the praise with which it was surrounded, has till now allowed it to remain uncontradicted. I do not think that I am much to be blamed, because, in common with others, I mistook this reticence for confession. Sir Arthur Cotton, however, at length gives us to understand that his silence arose, not from the consciousness of guilt, but from the pride of injured innocence; and I cannot hesitate to accept his explanation. Henceforward, then, craving for-

Sir Arthur Cotton's erroneous estimates for the Cole-roon, Godaveri, and other works were put forward in good faith, and that in setting down at less than half its real amount the expenditure to which he was thereby committing his employers, he was merely making the same sort of professional blunders as those recently committed on certain works of the Madras Irrigation Company; which, however, seeing that they have been undertaken under his auspices, Sir Arthur Cotton has, with characteristic courage, ventured to make the subject of self-glorification. This leads me to the second passage in my last pamphlet, to which Sir Arthur Cotton takes exception.

Sir Arthur Cotton had thought proper to contrast certain works proposed by myself on the Ganges Canal with certain works of the Madras Irrigation Company. He says, "Compare the work now advocated with what is now nearly accomplished by the Madras Irrigation Company on the Tumbudra river at Kurnool: which river is there about 150 feet below the water-shed immediately south of the confluence of the Tumbudra and Kistna. The Company have constructed an anicut or weir more than $1\frac{1}{2}$ miles in length across the river, and thus have also nearly completed a canal to carry 400,000 cubic yards per hour (3200 cubic feet per second) for 72 miles, through a very difficult, rocky, and undulating country, including a stone aqueduct across the Hindri river of 300 yards' length, crossing also several small streams, besides a considerable rocky cutting through the water-shed itself: and the whole of this will have cost, I believe, 200,000*l.*, or say 250,000*l.*"

Upon this I remarked that up to April, 1863, nearly 36 lakhs of rupees, that is to say, 360,000*l.* sterling, had

in the month of August, four months later, was as follows :—

“Anicut at the Sunkasala Head, incomplete, with a breach in it of 80 or 100 feet in width, which the engineers were about to attempt to close: on this work nearly double the amount of estimate had been expended, and it was as yet incomplete. The Hindri aqueduct incomplete, and all the money of the estimate spent. The excavation of 72 miles exceedingly incomplete, no bridges built, and in fact very few bridges had been estimated for. On 17 miles between the Sunkasala Head and the Hindri aqueduct there were no bridges. The embankments were imperfect and unconsolidated, and great damage had been caused by breaches during the rains. Many miles of the canal had been constructed intentionally and for economy's sake *without any embankments at all on its right, the water being allowed to find its own level by inundation over the surface of the country*; not much, I should say, to the benefit of the people in a sanitary point of view.”

Whereupon Sir Arthur Cotton, forgetting that in entering upon his pet Irrigation Company's domain, I had merely followed his guidance, somewhat unreasonably complains of my having travelled out of the public path, and judging, no doubt, from his own experience, expresses a fear that in so doing I may have soiled my hands. It was, he explains, only to *certain specified works* that he referred as likely to cost 200,000*l.* or 250,000*l.*, whereas I, who, as a member of the Council of India, and of the Committee of Public Works, had no excuse for not knowing better, had assumed, as the expenditure on those specific works, more than the whole of the Irrigation Company's expenditure on *all* their works. In confirmation of his own accuracy on this point, he brings forward the following statement, supplied

to him by the directors of the Irrigation Company, of their expenditure at the time named by me.

“The total expenditure incurred by the Madras Irrigation Company, on the 1st of April, 1863, was 334,554*l.* This included preliminary expenses, cost of management, stores, &c., connected with the whole scheme, the main canal of which is over 600 miles in length, and a large quantity of stores was also then in hand.

“Of this 334,554*l.* there had on that date been expended in and on account of the particular works specified by Sir Arthur Cotton, including a very liberal proportion of all general expenditure, 196,000*l.*”

This explanation may at first sight seem complete, and the ingenuous reader will scarcely conjecture in what way it may be set aside. My reply to it is simply that the *specific* works singled out by Sir Arthur Cotton were (with exceptions almost too insignificant to mention, though they shall be mentioned), really *all* the works which the Company had—*not* constructed, for most of them are not even now much more than half finished,—but begun to construct on the date in question. This will be placed beyond doubt by reference to the directors’ report to their shareholders, dated 1st May, 1863, from which it will be seen that, with the exception of some arrangements with contractors and the collection of materials for the Somaiswarum anicut, nothing whatever had been done in the way of constructive operations beyond the seventy-second mile, the extreme limit of Sir Arthur Cotton’s selected works. But further, these selected works had, according to the directors’ admission, then already cost within 4,000*l.* of 200,000*l.*; yet not only were they then unfinished, but not even now do the directors (see their report dated May, 1864,) venture to promise when they will be finished. The Hindri

aqueduct, the most difficult and expensive of all, still wants one-third of its intended breadth. Who can doubt that by the time when everything is complete to the seventy-second mile, the expenditure upon that part of the Company's work will be at least twice as much as it was in April, 1863, or more nearly 400,000*l.* than either the 200,000*l.* or 250,000*l.* of Sir A. Cotton's estimate, or the 360,000*l.* assigned by myself? But next, with reference to the very low figure to which the directors limit the expenditure up to April, 1863, on Sir A. Cotton's selected work. Their total expenditure up to date was, they admit, 333,554*l.*—say, 334,000*l.*—but of this only 196,000*l.* had been spent on the works in progress. What then had become of the odd 138,000*l.*? Part had, it seems, been expended in stores, of which the directors say a large quantity was then on hand; that is to say, the stores had not, on the 1st of April, 1863, been actually expended on the works in progress. But if the stores were purchased for the works then in progress, it was strictly accurate to say that the money they cost had been spent on those particular works. It would be strange casuistry to argue that the price of the bricks and mortar which had been bought to build a house, had not been spent upon the house, because the house was as yet only half finished. What was the value of the stores in hand is not stated, but whatever it was, it may fairly be added to the rest of the outlay on the works specified by Sir Arthur Cotton. Let us, for the convenience of round numbers, suppose the value of the stores to be 38,000*l.*; this, added to the 196,000*l.* admitted by the directors, will raise the cost of the works in question to 234,000*l.*, leaving a balance of 100,000*l.* out of 334,000*l.* to be accounted for by the directors. According to them, it has been spent in preliminary expenses, cost of management, and in connection

with portions of their scheme, other than those on which the 196,000*l.* had been expended, “a very liberal proportion of all general expenditure” being, according to them, included in the last-named sum. What, then, were these other portions of the scheme?

There was next to nothing to show upon them at the time. What little constructive work had been done, had been done above the seventy-second mile. Surely, then, it must have been in the “general management” of these last works that the bulk of the 100,000*l.* must have been expended; and I can have committed no very serious error in assuming that it was so, and that, consequently, the whole of the Company’s expenditure up to April, 1863, had been incurred on account of the only works of theirs which were at the time in existence. — It is absurd to suppose, as the directors would seem to do, that the cost of management during years already past can be distributed over the operations of future years. Every future year will assuredly have its own fully sufficient expenses of management, and those expenses will be chargeable on the things managed during the year, and on no other. I suggest this view of the case on behalf of the directors, who, if they will not accept it, must explain how, while spending 196,000*l.* on actual work and on the management of that actual work, they contrived to expend 100,000*l.* more in managing something else, which, whatever it be, has no tangible or visible form.

So far with regard to the second question, I need scarcely say “*Peccavi.*” Yet I have intimated that there are two points respecting which I feel called upon to excuse myself; and I proceed to confess in what consists my second error. I said that the expenditure of the Madras Irrigation Company “up to April” was nearly 260,000*l.* while the directors no doubt correctly state

it as only 334,000*l.* My explanation is that I had in view the period to the *end of April*, or the *close of the official year*; to the date, in *fact*, when the annual accounts are closed, and when the *cash expended* and the work done are made to confront each other—whereas the statement of the directors applies to the period ending with the 31st March. The difference of a month between us will sufficiently account for the difference of our figures.

Having had considerable doubt whether I should go on with this controversy, to which there appears to be no end, I have delayed taking any steps in the matter; but it struck me that the two points above alluded to required some notice, short as it might be. It will be seen that I have limited myself to the smallest space, and have tried the patience of my readers as little as I possibly could. With these few words I resign my pen into the hands of Sir Arthur Cotton.

November 1st, 1864.

P O S T S C R I P T.

30th November, 1864.

I HAD written so far, and was, indeed, on the point of sending my manuscript to the printer's, when an article appeared in the *Times*, which led me for a while to suspend my purpose. I was at first mute with astonishment, that the Jupiter of the press should have suffered its lightnings to be wielded by an avowed partizan in a private discussion, of whose merits it evidently knew as little as it cared; and I felt, besides, that there was little chance of my voice being listened to until the echoes of the thunder had subsided. I had no intention, however, of remaining silent under the misrepresentations of an anonymous assailant, simply because he was allowed to shelter himself behind the ægis of the *Times*. On the contrary, it is principally because his perversions of the truth have been ignorantly endorsed by so high an authority, that I think it worth while—as I now proceed to do—briefly and seriatim to expose them.

But before examining in order the specific charges brought against me by my anonymous critic, I must refer for a moment to his comparison between the returns of between 50 and 100 per cent. on their cost, with which he credits certain hardware dealers, with the

Madras presidency constructed under the auspices of Sir Arthur Cotton, and the 3 per cent. which is all that he vouchsafes to the Ganges Canal. Every one who knows anything of the matter, knows perfectly well that the real explanation of this enormous difference lies rather in the fact that Sir A. Cotton and his advocate attribute to his hydraulic works the whole increase which has taken place in the land revenue of the neighbourhood since his works were planned, whereas in North-Western India the revenue set down to the account of irrigation consists merely of the amount of the very low water-cess paid by the cultivators.* In the North-West the land revenue has been fixed for a term of thirty years. At the end of that period it will, no doubt, be largely increased, and all the credit of the increase derived from irrigated land may, according to Sir A. Cotton's principles and practice, be claimed for the canals that irrigate them. When this has been done, I shall not object to have the Ganges Canal placed in comparison with those of the Godavery and Kistnah. And here, since I am provoked in self-defence to follow Sir A. Cotton's example of self-commendation, I shall take leave to refer to the report made to his Government by the late superintendent-general of irrigation, Colonel Turnbull, on the beneficial influence of the Ganges Canal during the famine year of 1860—the very year which, according to my critic, proved the utter inefficiency of the Canal. It covered, says Colonel Turnbull, with cultivation 600 square miles, which must otherwise have been parched with drought, and enabled them to produce grain enough to maintain nearly 1,400,000 human beings during an

* In the North-West the water-cess does not on an average exceed one rupee per acre. To show how very far this is below the value of the water to the cultivator, I may mention that four rupees is the rate which the Madras Irrigation Company are authorized to charge.

entire year, besides saving Government from the necessity of making remissions of revenue to the extent of at least 200,000*l*. This was done by a canal which the *Times* allows its readers to be told has paid only 3 per cent.

Coming now to the nineteen mistakes which I am said to have committed in the construction of the Canal, the first and foremost I find to be the omission to make a permanent dam across the river at the Canal's head, so as to secure a supply of water. My reply is, that as long as I remained in India, and for some years afterwards, as much water as the unseasoned Canal could safely bear, could be admitted into it without the aid of a permanent dam. I foresaw that such a work might eventually be necessary, but I wished as long as possible to save Government the large outlay it would demand. Whether the construction of the dam has since been too long delayed, is a question which it does not become me to answer.

My next mistake is said to have been that of cutting the whole Canal too deep, thereby not merely wasting money in needless excavation, but penetrating into a sandy stratum, through which the water of the Canal has leaked, thereby flooding all the contiguous country with stagnant water. Sir Arthur Cotton would have preferred carrying the Canal between embankments raised above the level of the adjoining land. I need only say in reply, first, that to have brought earth for such embankments from the requisite distance would have cost much more than what are termed my unnecessary excavations; and, secondly, that although the upper strata through which the Canal is cut are for the most part comparatively water-tight, yet even in them patches of sand occur—sometimes a few yards, sometimes a few miles in extent,—through which filtration might in

any case have taken place. In one part where the Canal approaches the edge of the low valley of the Ganges, leakage through the sandy soil could scarcely be avoided, and in that part it has proved a very sensible annoyance; but as for the flooding of all the contiguous country,—*risum teneatis amici*. The Cottonian imagination is singularly prone to the production of mirage.

I may add that, whatever may be the professional boldness of Sir Arthur Cotton, no English engineer, with the recollection of the Sheffield disaster fresh in his mind, would venture to carry a stream half as wide again as Regent-street, and ten-feet deep, through a populous country between two rows of earthen embankments each 350 miles in length, and necessarily composed in many places of loose, friable materials.

My third mistake is said to have been that of using brick for the whole of my masonry works, while the best stone for hydraulic purposes was procurable from the sub-Himalayas, and while boulders or “river pebbles,” as Sir Arthur calls them, might have been employed. I have vainly assured him that such pebbles were largely used by me. He tells me plainly that he does not believe me. I can only hope that other readers will be less incredulous when I now positively declare that, on the first nine miles of the Canal, from two to three-fifths of all masonry work, other than arching, is composed of boulders. At one time no less than four thousand tons of boulders might be seen collected on one spot, for only part of the requirements of one single work. As for suitable paving-stone being procurable at a cheap rate from the sub-Himalayas, the only ground for the supposition is, that in the holy city of Hurdwar, at the head of the Canal, wealthy nobles and a richly-endowed priesthood have consented to pay fancy prices for the materials of palaces, temples, and bathing-ghauts. It might as well be argued

that Portland stone costs less in London than brick and stucco, because St. Paul's has been built of it. To the reviewer's assertion that I have admitted that suitable stone might have been placed on the works at one shilling per foot, the shortest reply will be the best: I never admitted anything of the sort.

Fourthly, I am condemned for arranging for the admission of all the water into the Canal at its head, instead of constructing a second dam, 200 miles or so lower down. Sir Arthur Cotton, I presume, estimates the cost of introducing the requisite supply of water by means of two dams, with a subsidiary canal from the second, at less than it would be with one dam only. According to my calculation, on the contrary, the expense would be greater in the former case. This is, indeed, merely matter of opinion, but, as I have shown in the first portion of this paper, trustworthiness in estimate-making is not Sir Arthur Cotton's strong point.

Fifthly, it is objected that all the weirs are of a length corresponding with the full breadth of the Canal, instead of being only one-third of that breadth, thereby entailing not only double cost in construction, but rapid subsequent destruction of the weirs. But the weirs are in eight distinct portions, and to assert that three openings will not stand three-eighths of the whole shock of water, and in the same breath to recommend that they should be subjected to the whole shock, is an absurdity of inconsistency which by refuting itself relieves me from the trouble of answering it.

Sixthly, the too great slope of the Canal is referred to. That this was a real and serious mistake, I have from the commencement of this controversy acknowledged, believing that I had to do with a generous antagonist, and not suspecting how disingenuous an use

had no precedent to guide me, no other engineer having ever had to deal with such a volume of water. I risked something in order to avoid the expense of a number of falls fully proportionate to the slope. Experience has proved that I risked too much, but the remedy for the fault is obvious, and its application will render the Canal more secure and effective than if it had been constructed on Sir Arthur Cotton's principles.

Seventhly, I am charged with mistake in placing the weirs in the direct line of the Canal, and cutting channels with locks in them on one side of the main canal for navigation. Sir A. Cotton would apparently have led the greater part of the water round in a curve for irrigation, and the remainder in a straight line for navigation. Here is involved a purely engineering question, on which I should await with confidence the verdict of any really competent tribunal, but on which a nameless writer in the *Times* has certainly no vocation to pronounce *ex cathedrâ*.

Eighthly, I am charged with not having made adequate arrangements for the removal of silt. This charge is based on a complete misconception of my quoted words, but my arrangements for the purpose in question were at any rate less defective than those in the canals of the Kistna delta, where the accumulation of silt has become so great as to compel the engineers in charge to recommend the abandonment of navigation on many of them.

Ninthly, the charge of needless expenditure on the Solani aqueduct is assumed by the reviewer to have been admitted by me because I have only once denied it, whereas it has been twice urged by Sir Arthur Cotton. For the reviewer's satisfaction I will now make the balance even by repeating my denial.

The next nine allegations refer to obstacles which my

plan of construction is considered to have opposed to navigation, and I am specially denounced for having presumed to question the practicability of combining effective navigation with effective irrigation. All doubts on that point are asserted to have been triumphantly removed by the experience of the Rajahmundry canals; but what I have said above in answering the eighth charge, shows that these shouts of triumph have been somewhat premature, and even if the combination in question had proved perfectly successful in short delta canals, no safe conclusion could thence be drawn with respect to an inland canal 350 miles in length.

Finally, the course taken by the reviewer in advocating Sir A. Cotton's proposal to construct a dam across the sandy bed of the Ganges, the neglect of which constitutes my nineteenth offence, is peculiar. "The result of the discussion," he says, "seems to be that out of nineteen mistakes asserted to have been made on the Ganges Canal by Sir Arthur Cotton, there is only one (referring to the dam aforesaid) about whose correctness there can be much doubt, and the presumption is that he is right in that case also." This reasoning suggests its own reply, with which I shall conclude these my positively last words on the whole subject. Sir Arthur Cotton having been shown to have been wrong in so many instances, the presumption is that he is wrong in this one also, as he certainly is when he goes on to assert that adopting the site proposed for his dam, and proceeding on the principles he has hitherto advocated, he could commence irrigation twelve miles from that site. But sometimes he speaks of irrigation commencing fifty, sometimes twelve, miles from the dam, with a variableness which very unnecessarily increases previous distrust in the stability of his estimates. I accept implicitly his disclaimer of having ever intentionally submitted fallacious estimates: but if any

additional proof were needed that his estimates, however well intentioned, are exceedingly apt to be fallacious, it would be furnished by his assertion that he could dam the Ganges in the way the reviewer commends, for 75,000*l.* This is quite sufficient to show that he knows as little of the cost of work in North-Western India, as he says I do of the *modus operandi* in the Madras territories.

One point still remains on which I am desirous of setting right those whom my reviewer has misled. According to him, Lord Canning, "convinced that there must be something wrong in the principles on which the Ganges Canal was constructed, and that the Madras School of Engineers must understand the science of hydraulic works better than their rivals in Bengal, employed Colonel Rundall to take a rapid survey of the Ganges Canal; and report upon its immediate requirements." This is the reviewer's account. The simple truth is that Colonel Rundall, happening in the winter of 1861-62, to be at Calcutta on some business of his own, or of the East Indian Irrigation Company, his employers, was recommended by his brother officers of the Bengal corps not to return to his own presidency without visiting the Canal. It was Colonel Yule, of the Bengal Engineers, then Secretary to the Government of India, who got Lord Canning's leave for him to go, and who suggested that he should submit a report on the results of his observations.

LONDON :
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OLD BAILEY, E.C.

REPLY

TO

SIR PROBY CAUTLEY'S

VALEDICTORY NOTE

ON THE

GANGES CANAL.

BY

MAJOR-GENERAL SIR ARTHUR COTTON.

LONDON:

PRINTED FOR PRIVATE CIRCULATION

1865.

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REPLY,

ETC.

It seems to me of the greatest importance to India that this subject of irrigation and navigation should be still kept before the public, and that everything that can assist them to judge of the matter should be placed before them. I am, therefore, very glad that another pamphlet has appeared from Sir Proby, and that thus another opportunity is given me of meeting what has been so long said and fancied in private, and by many taken for granted, because no opportunity was given for hearing the other side. I am far more than satisfied with the controversy so far, and am quite sure that many have far more correct notions on the subject than they once had, through this discussion.

Sir Proby begins his present paper by announcing that dams are not likely to be built in the "*trough*" regions of the North-West, from which I conclude that he has succeeded in obtaining the sanction of the authorities to his views so far, that nothing shall be done about the weir below the Solani. They are certainly quite in the right; for the construction of that work would indeed be a dangerous experiment for them, as it would effectually confirm my arguments. However, notwithstanding their determination, I fully expect that it will be built before long. I

am, therefore, obliged to differ in this also from Sir Proby, that "there is little chance of practical experience on this "subject." I feel sure that there will speedily be practical experience on this subject.

He then proceeds to assure us still that "ultimately "the problem of combining irrigation and navigation will "prove as difficult to solve in Rajahmundry as it has been "in the North-West." One would suppose that what had been going on with perfect success over about one thousand miles of canal, some of it for fourteen years, was pretty well proved to be practicable! We may require a discussion next whether a locomotive can draw a train by merely making it fast to it! I wonder whether that operation will ultimately prove a hard problem to solve. A former Governor of Madras took to himself great credit for knowing that the Godavery Anicut would not stand, when it had stood for five years, and it was still standing, and there it is now.

How much more it would save men's character in the eyes of the world if in such cases they were to say, "Well, "I certainly was mistaken in my former thoughts on this "point."

Probably 120,000 boats have passed through the main canal since it was opened in 1851, including 16 passenger boats a day, when I was last on the spot.*

The rest of the pamphlet, which purposes to be a reply

* A return I have just received gives 18,000 boats as passing the head of the main Canal last year, the navigation of this Canal having thus continued and increased for 14 years, without interruption, except occasionally for repairs. The first year, there were about 800 boats, and the average tonnage then probably not half of the present, so that the traffic has increased about 40 fold in 13 years.

to mine, is occupied about Colonel B. Smith's and his own publication of a most absurd statement about me personally, without one word of proof (happily so absurd that it carried its own contradiction on the face of it), and on the cost of the Toombuddra works. About these things there does not seem any necessity for my taking up the time of my readers.

In his pamphlet Sir Proby replies to a paper in the *Times*. On one or two points in this I may as well add my remarks. Sir Proby says that every one who knows anything of the matter, knows perfectly well that the real explanation of this enormous difference between the returns from the Ganges works and those from the Godavery works lies rather in the fact that "Sir A. Cotton and his advocates" attribute to his hydraulic works the whole increase which "has taken place in the land revenue of the neighbourhood; whereas in the North-West the revenue set down to the account of irrigation, consists merely of the very low water cess paid by the cultivators." No assertion can be more contrary to fact than this. There is not an individual who has inquired at all into these matters that thinks the Ganges Canal Works have yielded the same profits as the Godavery works, or in any way returned 40 per cent., £1,100,000 per annum net, into the treasury. In a letter from the Government of the North-West Provinces, dated August, 1862, the gross returns from the Ganges Canal are stated at £60,000, or about 2 per cent. upon the outlay and interest, perhaps a little more than covering the expenses, and if we double this on account of increased land-tax, it will give perhaps a net return of £70,000, instead of £1,100,000. Nothing can possibly be more distinct than the local Governments' reports upon these works, and those

“ true test of the success of a canal, as far as the Govern-
 “ ment is concerned, is found in the returns for the capital
 “ expended. The Ganges Canal may, it is hoped will, stand
 “ this test hereafter ; but tried by it now, it can scarcely be
 “ pronounced successful.” Again,—“ A beginning has
 “ been made during the year under review, and the Lieu-
 “ tenant-Governor trusts that the anticipations of the
 “ Superintendent-General in respect to the canal *continuing*
 “ *to pay its expenses*, and in due time returning a fair
 “ profit, may be realized.” This was written 18 years
 after the commencement of the work, and in the year when
 the Godavery works had paid into the Treasury more than
 1½ times what had been expended up to that time, after
 deducting repairs. In the last Report on the Ganges Canal
 that I have, by Colonel Turnbull, that for 1862-3, the
 capital and receipts are stated to be,—

Cost of works	£2,006,000
Interest, maintenance, and repairs . .	1,000,000
	<hr/>
Total	3,007,000
Gross proceeds up to end of 1862-3 . .	260,000
	<hr/>
Balance against the works	£2,747,000

And the ordinary expenses and receipts for the year 1862-3
 are—

Charges	£63,000
Receipts	53,000
	<hr/>
Loss on the year	£10,000

So that, that year,* after spending 2¾ millions, the works
 did not pay their expenses, according to the accounts.

* The extension of distribution since that year ought to
 have produced a proportionate increase of returns, but I have
 not been able to get the returns of the last season.

But I think from what I have before stated respecting the increase of land revenue, which is so absurdly not entered in these accounts, that there may be really a similar sum—viz., £53,000—properly to be credited to the canal, and this would leave a net profit for the year of £43,000, or $1\frac{1}{2}$ per cent. on the capital. This is the utmost I can make out in favour of the works, against £1,100,000, which would be the profit at the rate of 40 per cent. It must, however, be known that the receipts of this year were £17,000 below the preceding in consequence of the failure of the brick weirs, obliging the engineers to shut the canal for three months in the midst of the irrigating season; this sum would be an additional $\frac{1}{2}$ per cent.

I am sure it is impossible we can be wrong in concluding from these testimonies of unbiassed persons and from the accounts, that this is a substantially correct view of the results of the two principles of projection which have been adopted in the two Presidencies; and hence, that the failure of the Ganges Canal, though it proves that wrong principles of construction were adopted in the North-West provinces, is no argument at all against irrigation and navigation; for we have only to adopt the Madras principles of construction in future projects to obtain similar results where the country is equally favourable.

The language of the Madras Governor about the irrigation works there, was, “The increasing prosperity of the district is most vividly marked in every way.”

“The importation of bullion was £190,000 (in that year).

“The present state of the district as compared with its previous state may be briefly summed up as follows—the

“*revenue has been doubled, &c.*” This was the same year as the above letter of the Governor of the North-West

And another despatch of the Madras Governor says, in a

letter dated 15th May, 1858, "Further, the Government
 "question, whether, considering the returns from irrigation
 "works are always considerable, and often immense, &c.;"
 and "that the irrigation works be looked upon and prac-
 "tically treated as being—what in fact they are—the most
 "economical, because the most profitable in which the
 "Government could possibly engage. It is needless now
 "again to bring forward the innumerable instances in which
 "money has in this Presidency been most advantageously
 "invested in irrigation-works."

It is impossible to mistake the comparative tenor of these two opinions of the local Governments on the Ganges and on the Madras Irrigation Works, or that anything could be said that would more completely overthrow Sir Proby's above-quoted assertion, that there is really no difference in the results of the works. And on the results of the Tanjore works separately, the following are extracts from the letter of the Madras Board of Revenue, dated 21st May, 1855—most unexceptionable testimony, also, as coming from a body of civilians:—"So that for an outlay of 217,000
 "rupees, the Government have received a clear gain of
 "4,120,000 rupees in 16 years, or a profit of 118 per cent.
 "per annum"—from the very first year; the total being nearly 20 times the whole cost of the works! Again—
 "But this result of the Anicuts, great and gratifying as it
 "is, does not comprise all the truth; losses of revenue
 "have been prevented, besides an actual addition being
 "made to the resources of the Government. And the
 "people have benefitted by the increased productiveness
 "and value of their lands." "Thus, the principal collector,
 "Mr. Kindersley, when alluding to the disastrous year 1836,
 "observes, "Without the Anicut, the failure of the crops
 "must have been incalculably greater than it was. Indeed,

“from the very nature of the work, its operation is much
 “more advantageous in a bad year than a good one, and I
 “have not the slightest doubt that the saving it effected in
 “1836, when it gave a full river but for 68 days, was much
 “greater than the profit derived from it in 1837, when the
 “river was full for 122 days.” “In the 6 years before the
 “Anicut, the remissions of tax granted for withered rice-
 “crops were, from 1830 to 1835, 843,000 rupees; in 6
 “years after the Anicut, from 1837 to 1852, they were
 “only 369,000 rupees.” “Another test of the benefit con-
 “ferred by the upper Anicut is the value of irrigated land
 “at different periods. The statement prepared by Mr.
 “Forbes supports this fact, by showing that the *average*
 “price per valy (7 acres) was 82 rupees immediately before
 “the construction of the Anicut, and that it has risen to
 “95, 107, 135, and 174 rupees, in the following quinquen-
 “nial periods”—an increase of 92 rupees per valy, or 13
 rupees (£1 6s.) per acre, which average applied to the
 1,200,000 acres of the Delta, would be more than 1½
million sterling added to the saleable value of the land
 (equivalent to 7½ millions in England, allowing for the
 difference in the value of money, five to one), besides the 118
 per cent. of direct returns to Government. “An increasing
 “population, a Government which encourages and protects
 “industry, and a regular revenue administration, must have
 “had some influence on the value of land; but the Board
 “attributed the rise in its price principally to the improved
 “irrigation conferred by the Upper Anicut, and Government
 “expressed its concurrence in this view. The advantages
 “conferred on Tanjore by this work received the following
 “emphatic testimony from the P. Collector, Mr. Kin-
 “dersley, shortly after its construction; and subsequent
 “experience appears to the Board to confirm its justice:—

“ ‘ I cannot conclude without observing that while doubt
 “ ‘ appears to be entertained of the advantages of the Ani-
 “ ‘ cut elsewhere, there is not an individual in the province
 “ ‘ who does not consider it the greatest blessing ever con-
 “ ‘ ferred upon it.’ ”

The above extracts from the letters of the Board of Revenue referred to the years 1852-53, when the revenue of Tanjore was £485,000. The district has gone on advancing since then, and is now, on the average of the last 2 years, £636,000, an increase of £150,000 a year, most of which is due to the command of water given by the Anicut, though much money was certainly expended in detail works required to distribute the water so obtained.

But so perfectly satisfied is Sir Proby himself on this point, that in all this discussion he has never attempted to show that the Ganges works have as yet really been profitable to Government at all. There is certainly no question about it.

In a note Sir Proby says that “ in the North-West the
 “ water-cess does not on an average exceed one rupee per
 “ acre. To show how very far this is below the value to
 “ the cultivator, I may mention that four rupees is the rate
 “ which the Madras Irrigation Company are authorized to
 “ charge.” This is a curious note. What has the rate authorized for the Madras Irrigation Company to do with the comparative profits of the Ganges and Godavery works ? The rate per acre on the Godavery is 3 rupees, and Sir Proby might have added, *for rice*, which requires about six times as much water as wheat, the crop of the North-West ; so that they there sell the water at about double the price that is taken on the Godavery.*

* The Government of India have just ordered the water-cess on the Ganges Canal to be raised to 24 rupees per acre.

That the Ganges Canal was of immense value in the famine is certain, and I have strongly insisted on this in my papers, pointing out how it provided "food for $1\frac{1}{2}$ millions of people, besides the means of conveyance for vast quantities brought from other places." I also insisted upon the absurdity of taking part of the water-rate in the form of land-tax, so that the canal accounts did not show the whole of the returns; and I showed from some data afforded by Colonel Smith, that probably the actual returns were about double those shown in the accounts, or 6 per cent. gross.

But this was not the question. The question was not, Had it been of no use at all? but had it failed in the main to effect what it ought to have done through defects in the projection? and was it consequently, in fact, no sound argument against the extension of irrigation on true principles? Colonel Baird Smith shows that in the famine 80,000 persons died in one part of the famine tract; that the water could not be thrown into the canal at the very time when it was most wanted; and that, owing to the extreme defects of the navigation, nothing like the use was made of the canal for carriage that was wanted; besides that it had not made anything like adequate returns in money: and what I have tried to show is, that this is not from anything wrong in the theory of irrigation; but from mistakes in reducing the theory to practice in this particular instance. Nobody can be less inclined than I am to keep out of sight the incalculable benefits afforded by the canal in the famine, or any other fact. My sole object has been to show, by simple arguments drawn from actual results obtained in similar situations elsewhere, that these works might have been so constructed as both to have been in full operation both for irrigation and navigation, before the

famine occurred, and also to have made as large returns at least as those works which have succeeded.

Sir Proby next proceeds to defend his non-construction of a permanent weir on the ground that he deferred the expense as long as possible, though he foresaw that such a work might ultimately be necessary. I certainly have no right to find fault with this principle, for it has been a leading one in all my projections, viz—to spend no money on anything that was not absolutely necessary at the time. But it is strange that he should stretch this principle to such a degree as to apply it to the fundamental work, which would have added perhaps £50,000 to an expenditure of 2 millions, or an addition of $2\frac{1}{2}$ per cent. for a work of such immeasurable importance, while he spent more than double that sum in bridges; and while in fact in all other parts of the projection he totally lost sight of that principle. But, as I have said, it is a matter of no importance whether it was right or wrong at the time; the only question I had to deal with was, what mistakes and defects now appear which have caused the failure of the project in respect of returns, so as to make it the grand argument against irrigation in India instead of the main one for it, as it ought to be.

I need not go again over the ground of the deep cutting for the canal upon which he enters, as I have already discussed it. But I must say that Sir Proby must be hard pushed for a defence when he brings in the bursting of the Sheffield Reservoir, with its 90 feet of water behind it, as an argument against a bank to bear 5 or 6 feet. We have thousands of miles of such embankment to our rivers and canals supporting a few feet of water, and this objection therefore is entirely imaginary.

Sir Proby then says that the comparative expense of making dams lower down the river, and bringing the water all the way from Hurdwar by canal, is a mere matter of opinion.

This is the usual way of evading conclusive arguments. It is not a matter of opinion; it is a matter of calculation, and that so simple that it can be made in a few minutes in a form perfectly to satisfy even non-professional men. After building so many great weirs we have perfectly safe data. The actual comparative cost of the two plans may be thus safely estimated:—

Actual cost of the canal from Hurdwar to	
Meerut about	£1,000,000
Weir below the Solani	£75,000
50 miles of channel to Meerut at	
£2000	100,000
	<hr/>
	175,000
	<hr/>
Saving	£825,000

or two-fifth of the whole cost of the works up to this time, which is £2,000,000.

Sir Proby, in his remarks about the silt, says, “But my arrangements for the silt were, at any rate, less defective than those in the canals of the Kistnah Delta, where the accumulation of silt has become so great as to compel the Engineers to recommend the abandonment of navigation on many of them.” I do not see how the officer who planned the Kistnah works (Colonel Attwell Lake, of Kars), having made an omission, can exonerate another officer from having made a similar mistake.

The fact is we have all made the same, and a very serious one it is. It has so happened that in the Godavery works the omission has not very seriously injured the

working of the canals, but this is not owing to any better management of ours. It was a great mistake, and now appears plainly enough.

I understand the effects of it were much more seriously felt on the Kistnah than either on the Ganges or Godavery, in consequence of the much greater deposit of silt there. But this does not the least justify the deliberate mistake of making some of the canals there not navigable.

The remedy that Sir Proby speaks of above—viz., to recommend the abandonment of navigation—is a thousand times worse than the disease. The reason of this desperate step being taken on the Kistnah is no doubt that the works have been lately under charge of an officer brought up in the Bengal School of Engineering, and who had consequently no right apprehensions of the essential importance of cheap transit. The remedy, or at least one perfectly simple and sufficient remedy, is to enlarge a portion of the main canal near the head, so as to diminish the current there, which will cause the deposition of the silt, where there is room for the dredges to work all the year round without interfering with the navigation. This would be a very insignificant expense. It ought to be immediately applied to all the great works now in hand, unless a better remedy could be found ; but I don't think any could.

There seems no occasion for me to go further into these several particulars touched upon in his reply to the *Times* paper.

As for his charges of "misrepresentation and perversion of the truth" against the writer of that paper, I may safely leave it to the readers of the discussion and that review of it, to decide whether there is a shadow of foundation for them, and certainly if Sir Proby could have proved them he wouldn't have been content with a bare assertion.

I must, however, notice one of his remarks to show how inveterate imaginations are.

He objects to the single embankment on the Toombuddra across the valleys, "the water being allowed to find its own level over the surface of the country, not much, I should say, to the benefit of the people in a sanitary point of view." There are perhaps 100,000 tanks scattered over the Peninsula, and because the Engineers have been troubled by fever in certain circumstances in the North West, Sir Proby dreams that sanitary considerations absolutely require that an Engineer should not make a new tank in Madras. These tanks are, as I have said, the very things that are wanting both in the Ganges and in the Madras works, as depositaries for silt, where dredges can be kept at work without hindering the navigation.

I may also add my remarks upon Sir Proby's saying, "if any *additional* proof were needed " that his estimates, "however well-intentioned, are exceedingly apt to be fallacious, it would be furnished by his assertion that he "would dam the Ganges for £75,000 ; this is quite sufficient to show that he knows as little of the cost of "work in the North West, &c." This is a very safe paragraph. Sir Proby first speaks of *additional* proof; he has given no proof whatever; he has indeed asserted and insinuated it over and over again, but without one word of proof, which one may be perfectly certain he would have given if he could, from the whole tone of his papers. In this respect also I have been just like other Engineers; some of my estimates have turned out inadequate, but many of them pretty near the actual cost. I have not failed in this point remarkably. I have certainly never indulged in what are mildly called liberal estimates, by which the Engineer tries to save his own reputation at the expense of

his employers; but I have always endeavoured to give strict estimates, that is, as near as I could judge what the real costs of the works would be, for in practice it will be found that the only effectual check upon wasteful expenditure is a strict estimate. But an estimate is and must always be an estimate; and if an Engineer had had 100 years of experience he could never undertake to certify what a work would actually cost.

And he does not attempt to answer my arguments, or to show by a single argument of his own, why such a dam could cost more than £75,000. The Godavery Anicut, which is built where the river is 4 miles broad, 30 feet deep in the freshes, and discharges 200 million cubic yards per hour, cost £85,000. The discharge of the Ganges at the Salani is about $\frac{1}{6}$ of the above, so that the corresponding price would be £14,000; to allow for the rise of prices, now nearly double, and the conveyance of most of the materials by water, about thirty miles, I have allowed five times the proportionate cost. It is entirely out of the range of probability that it should exceed that proportion.

Sir Proby brings forward Colonel Baird Smith to support him, not only in circulating an unfounded report about me, but in general as to the principles of construction.

Colonel Smith's remarks on the Madras Works are a most curious specimen of false schooling, habit, and prejudice. He came to Madras and saw evidently successful works, and he deliberately concluded that the principles on which they were constructed were all wrong; and returned confirmed in his previous idea, that the principles of construction adopted in the works which had failed, were all right. Nay, he actually pointed out the very things that were such proofs of entire ignorance of all right principles

in our works. Instead of employing ourselves in cutting canals for the purpose of building bridges over them, we had occupied ourselves with turning the water on to the land; and instead of waiting a few years, till we had cut capacious canals (all below the level at which the water was wanted, of course), we had turned the water into any old channel that we came across, merely for the purpose of letting it run at once over the fields and so on. To be sure, in this way we had from the very first paid our own way, and were, when he saw the works, expending on them only a small part of the actual increase of revenue produced by them, but this could not possibly justify principles which were settled in the North West to be quite wrong. On the other hand, there, they had spent five times what we had, and had yet no returns nor any prospect of them for some years to come, but then they really had something *to show* for their pains—an immense excavation, and noble bridges at every three miles, &c. They had not the swarms of boats navigating it that we had on our canals, but every Engineer brought up in the North West school would much prefer to see things done on orthodox principles, whatever the consequences. It is evident that it never once entered Colonel Smith's head that *our* system, which had produced the result intended, and far beyond what people expected, must be right, and that that which had produced no results worth mentioning must be wrong.

The truth is that it is perhaps an inevitable, but a regrettable consequence of the excessive centralization of Indian Government, that the officers of the Bengal Presidency, who are constantly coming in contact with, and are familiarly known to the Supreme Government, and who have most influence on its decisions, come to look on the public

servants of the minor Presidencies as almost an inferior caste, and at least as a class necessarily less advanced than themselves; and no doubt Colonel Smith came down to Madras, not having been then enlivened like other people, by a famine in the very province traversed by the Ganges Canal, full of the notion that the Engineers of the Metropolitan Presidency, who were basking in the sunshine of the Governor-General's favour, could not *learn* anything from the officers belonging to a minor Presidency; obscure individuals of whom nobody had ever heard.

When Colonel Smith was at Madras, I presumed so far as to try and have a discussion with him. I called upon him and pointed out to him, that as he was then going up to take charge of the Ganges Canal, how extremely important it was he should take care to have a clear start, and not commit himself to any errors made by his predecessors, for even then they had begun unmistakeably to appear. I advised him to review carefully the whole project, as it stood, and with the help of what he had witnessed in Madras, inquire into what appeared wrong, and see what could yet be done to correct it.

But on the above-mentioned assumption that officers of the Metropolitan Presidency must be always superior, always in advance, probably Colonel Smith thought it presumption in me to offer such counsel, though I was so much older and had had such extensive experience.

It was indeed rather hard advice. If it had been followed he would certainly have lost all favour, and probably his appointment, for under the former *régime* such men as would persist in conscientiously pointing out what was wrong and what was wanting were immediately looked upon as troublesome and impracticable men, who must be

got rid of, if possible. If he had sent in a thorough review of the whole project, pointed out its defects, and earnestly proposed their correction, he would have been told that "they were not prepared" to make such changes; and most likely a more accommodating man would have been put in his place. But Colonel Smith stepped mechanically into his predecessor's shoes, endorsed all mistakes, and the consequence has been ten years' more expenditure, without any adequate returns.

There is every reason to hope that if he had been capable of learning a lesson and fighting such a battle, he would have saved India many millions.

But I must acknowledge that it is not every man that could have faced such a storm as the following of my advice would have raised. If the Ganges Canal had been returning 20 per cent., some men in Bengal, I am sure, would have been satisfied on the subject of irrigation and navigation, and would have heartily pressed on the extension of the system throughout India, as the Government of Madras had done so strongly. I feel confident that such would have been the case with Lord Canning, both from communications I had with him before he went out, and from what he wrote in the despatch quoted in a former pamphlet, where he says "we shall obtain the views of the officers of the Madras works," with respect to the plans for the Behar project.

Yet even Lord Canning was not very anxious to hear the plain truth. When he ordered me to Bengal to report upon the works for the protection of the city of Cuttuck from the Mahunuddy, he condescended to order his secretary to write to me giving me a hint of what kind of a report I was to make. I replied in my report that I did not come

there to give other people's opinions, or what I imagined they were, on those works, for I was surely bound to give my own conscientious and unqualified opinion, the fruit of such long experience as I had had, and not the opinion of those who had had none, and who were necessarily entirely ignorant of such matters.

In pointing out the real facts of the case, the success of the Madras works and the principles of projection and construction which, under God, produced that success, of course my opponents have a fine opportunity of charging me with boasting; it is a matter of great thankfulness that I have not a case to deal with, in which they might charge me with trying to conceal failure. As it is,

“ populus me sibi lat ; at mihi plaudo
Ipse domi, simul ac nummos contemtor in arcâ.”

I look at the rupees in the Government chest, and at the millions of people raised from poverty, and in a great measure secured from famine, and at the prospect of the extension of these beneficial works throughout India, and am not much disturbed by such hard words.

It is indeed terrible to think of the opportunity lost by Colonel Smith at that time when he went up to take charge of the Canal. Had that noble work been in full operation both for irrigation and navigation when the famine occurred, and had it been since returning 20 per-cent. ; had the Canal swarmed with cargo boats, and with large passenger steamers worked at a good speed, and at almost a nominal charge, it seems hardly possible that such a ruinous delay would have taken place in the great enterprize. And now another famine is stated to have actually commenced,* and pro-

* “The want of water is beginning to be felt in many localities. The late crops will suffer, and scarcity and dearness

bably nothing less terrible would be sufficient to overcome the inveterate determination not to prosecute it. Even the completion of the successful works is obstinately resisted. Only lately, money was ordered to be taken from the utterly inadequate means allowed for that, to be expended on tramways. Now that the large outlay for the heavy works on the Godavery and Kistnah are completed, the light expenditure in the distribution is yielding at least 100 per cent. in direct returns, and the money is diverted from that to works that do not pay the bare interest of the money.

✓Carrying on Madras works in our unpretending way, we are necessarily exposed to the censures of superficial men. If we had had immense excavations (with the water below the level of the land to be watered) and multitudes of bridges (too low to allow of loaded boats passing under them, and without towing paths, &c.), such men would be quite satisfied.

They never lift up the lid of the treasure chests, whether private or public, or ascertain whether the water has reached the fields, or take an account of the boats on the canals, or hear what the landowners or the merchants, or the money-lenders, or the labouring men or the women say. All such matters would be far below a great Engineer.

“of provisions will, it is feared, prevail to a dreadful extent.” —*Times of India*, Dec. 13th. On the 12th of December the Governor-General told the deputation who waited on him with respect to the Mutlah, and the construction of wet docks in Calcutta, that, “when a famine was impending in the North-West; “when the expenses of Government were exceptionally heavy; “and when a reduction in taxation is demanded,” it was not a favourable time for undertaking a costly enterprise.—*Home-ward Mail* of Jan. 21, 1865, p. 52.

His business is to see that *grand* works are executed, and *that* in an orthodox manner. None but small-minded men would inquire about the cash chests of the employers, or the stomachs of the employed. But such were in those days the grand oracles, and they are so still.

Witness the railways and their results. In the late reports there is not one word that can enable us to judge of the latter.

Nobody is informed what amount of goods and number of passengers they convey on an average along the line; what proportion those bear either to the numbers that do so travel, or that ought to travel in such a country, if transit were brought within their means, &c. From the reports nobody knows what effect they have produced—whether they have produced traffic, or are merely carrying 1-50th of the old traffic either in goods or passengers; what effect they have had upon the districts they have passed through; what the cost of traffic is on them as compared with that on a fair metalled road; what proportion of goods and passengers are moving just as they did before railways existed; what has been the effect of the heavy taxes imposed on the country to pay the interest of the capital expended, &c., &c. Not one single word is said upon any one of the important points of the question, nor is the slightest notice taken of the meetings of a Chamber of Commerce for the sole purpose of consulting what is to be done in consequence of the utter failure of a railway to carry even an insignificant portion of the *old traffic*. These reports are just like Colonel Smith's, they utterly fail in respect of all the great essentials of the question. We have thus positive proof that the reign of such superficial men is not over under the new *régime*.

These are not the men who are wanted. We want men who have nerve, discernment and uprightness, really to grapple with the realities of the case—who will not be content to take the safe side and prophecy smooth things, but who are both ready to sacrifice themselves in the conscientious performance of their duty, and who are capable of searching out a matter; men who have such extraordinary powers of mind, too, as to think of peeping into a cash-chest. It is impossible to estimate the mischief that this class of men do. They are certainly wise in their own generation, they are accounted as oracles, they are in high favour, they get good appointments, and they are perhaps not found out till they have enjoyed the profits of the line they have taken; *but they are the ruin of the country*. Had we had able, conscientious, public-spirited men who, whatever the consequences to themselves, would not rest till they had searched out results, and forced the truth upon our financiers and others, it is impossible that India could have been kept to this day without effective irrigation and effective transit, both for goods and passengers; while at the same time most oppressive taxes are added to the amount of two or three millions, to pay the interest of money ineffectively expended. Take notice of the following extracts from speeches of the leading merchants at Bombay at a meeting of the Chamber of Commerce:—

“The railway company have made public confession of their inability to do the work which the public are justified in expecting from them. in their notice that after a certain date they will cease to accept for carriage an article, &c. (cotton).”

“Already, the native cotton dealers, in despair of the railway company doing their work, are organizing a system

“ of carts to carry the cotton as it was carried probably
 “ 2000 years ago, and next year they hope to be indepen-
 “ dent of the company altogether. Is not this disgraceful?
 “ Do you not all feel humiliated? I
 “ declare that I feel ashamed that western enlightenment
 “ and progress should thus be degraded in the eyes of our
 “ native fellow-subjects.”*

Again.—“ That a double line of rails must be provided
 “ on both our lines, is becoming more and more apparent
 “ every day, &c.”

“ I trust that the lamentable failure of the G. I. P.
 “ Railway in its obligations to the public will not only act
 “ as a warning to them, &c.”

“ I believe that about one-fourth of the cotton that
 “ comes to Bombay is brought down by the G. I. P.
 “ Railway. The company pretended to be able to bring
 “ all the traffic of all the districts through which the line
 “ passes; but after leading the country to abandon and
 “ disorganize other means of transport, they have syste-
 “ matically failed to execute the work they have under-
 “ taken. At any rate, the experience of last
 “ year ought to have convinced them of the utter impos-
 “ sibility of managing the whole of the probable traffic of

* Compare this with the following extract from a paper
 by another of the class above spoken of in Charge of the Madras
 Railway :—

“ I have spoken of *the stimulus given to every class of the*
 “ *community and every department of commerce by this new and*
 “ **HIGHLY EFFICIENT MODE OF TRANSPORT.**”

It is certainly true that the railways have acted as a pretty
 strong stimulus to the Chamber of Commerce of Bombay, to
 judge from these speeches and from a second meeting some
 time afterwards.

“ this season, and they ought to have had the honesty to
 “ confess this, and give the public notice in time to re-
 “ organize other modes of transit.”

“ The net profits of the line have been—

For 1861	. . . . .	$1\frac{5}{8}$	per cent.
1862	. . . . .	3	„
1863	. . . . .	2	„
		<hr/>	
		3)6 $\frac{5}{8}$	
		<hr/>	
		2 $\frac{1}{4}$	

“ Now the difference between these per-centages and the
 “ guaranteed interest has to be paid by the treasury,—
 “ that is to say, out of our pockets, and therefore we
 “ have a double right to protest against mismanagement,
 “ the consequences of which do not fall upon the railway
 “ company, but upon the mercantile community and the
 “ *tax-payers* of India.” “ The G. I. P. Railway, on
 “ the other hand, from which we had a right to expect that
 “ it would be the means of bringing the cotton crop to this
 “ great port with the despatch of a railway, had ignobly
 “ failed, &c.”

“ A correspondent of the *Bombay Gazette* a few days ago
 “ wrote from Mulkapore, that he found at Bussora from
 “ 80,000 to 90,000 bales of cotton lying round the station ;
 “ thousands of bags of seed and other goods lying uncarted
 “ at Egutpora, &c.”

“ It is not simply matter of complaint that the line is
 “ unequal to its work, &c.”

✓ Here we see that a railway that was to “ *create traffic*,”
 “ a new and highly efficient mode of transport ” according
 to one of the propheciers of smooth things, not only could

not create the new traffic of 1 or 2 millions of tons that ought to be carried on that line, but literally could not carry one insignificant item, about 20,000 tons of the old traffic. But is it not beyond measure astonishing that of all the Government officers employed about these railways not one was found who would point out the utter absurdity of imagining that a single railway could carry even one or two millions of tons, and as many passengers? No wonder "we are degraded in the eyes of our native fellow-subjects" when the whole Railway Department could not produce an officer who had the manliness to keep this point in view. Do we not most richly deserve to be "disgraced in the eyes of our native fellow-subjects" when such has been our course of proceeding? These were the works that were to prove to the natives our superior wisdom, and to produce an immense impression of our intelligence. If we had cut a hole a foot square for an elephant to creep through, they would have been as much impressed with our acuteness. I have said that the Railway Reports said nothing to show us the quantity carried. They do indeed state the total number of passengers carried on the railways, but as they do not say how far they are carried, it tells us nothing; they may be carried on an average 10 miles, or 100, on a line of 1000. To tell us that a million passengers were carried on a railway 1000 miles long, tells us nothing. If each passenger is only carried on an average 10 miles, the actual traffic of the railway is 10,000 passengers a year; if 100 miles, the traffic is 100,000 passengers a year carried over the whole line. But even this statement amounts to nothing unless we give a standard at the same time by which we can judge of this traffic, whether for a certain line it is large or small, sufficient or utterly insignificant.

It is of no use to give a picture of the *Great Eastern*, unless you add something that the eye is accustomed to, to form a standard, as, for instance, a 3-decker, or some other well-known object.

Thus we are told that on the East India Railway 2,900,000 passengers were carried when 800 miles were open. What does this mean? It means that so many individual tickets were taken *on all the different parts of the 800 miles*; but whether each averaged 10 miles, 100 miles, or 800 miles, not a word is said. Thus a vague impression of vast traffic is left without anything being really known of the matter.

Then the whole number of passengers is divided by the number of miles open, and the result is given as the number of passengers conveyed per mile. What in the world does this show? It is simply the old question,—If you divide the ashes, by the poker, tongs, and shovel, what is the quotient? There were, for instance, by the last Report, 4800 passengers for every mile of road according to the statement. Now if these passengers travelled on an average 10 miles, the traffic over each part of the road was 48,000 a year; if 100 miles, 480,000 a year, and so on. And if we were told whether the number is 48,000 or 480,000, it still tells us nothing as to the real question of whether the railway is effective or not, unless we are told what proportion of the present travellers are compelled to travel as they did before, and unless we have an estimate of the number that would travel if the cost were reduced to what it might be. Now the actual state of the case is this. The whole receipts for passengers at that time on that line were, for the year ending June 30th, 1863, near £310,000,

mile at $3\frac{1}{2}$ pice (almost the whole were 3rd class at 3 pice, $\frac{3}{8}$ of a penny), the number travelling on an average throughout the line was about 680 a day, the number actually travelling on that line by the old means could hardly be less than five times that number, or 3500 a day; and we may be certain that if the fare were reduced to $\frac{1}{2}$ pice (one-sixteenth of a penny) for the lowest class, as it would be with water transit, that the present number would be increased at least five-fold; so that we have good grounds for judging that this railway carries *not one-thirtieth part of those that want to travel, and that an effective communication would accommodate.* And so with goods. By such reports as are published the true state of the case is effectually kept out of sight, and not one atom of information is given by which the public can judge whether the railways are really carrying the required traffic of the country either in goods or passengers, or whether they are as utter failures in respect of traffic as they are in respect of money returns.

The unfortunate thing is that in consequence of the guarantee, the official reporters, the managers and the shareholders, are all equally interested in keeping up the delusion, so that nothing but such utter failure as would bring down terrible direct loss on the European mercantile community, would probably ever lead to the truth being distinctly brought before the public. The extracts from the speeches of the chairmen and others of the Bombay Chamber of Commerce have, however, happily thus shown the real state of the case to a certain extent.

Of course this is only a very small part of the actual loss; the great loss is not on the things attempted to be moved, *but on ten times that quantity, which, on account*

of the enormous cost of carriage, cannot be thought of as moveable at all.

I will mention one point, which will put in the strongest possible light the enormous loss to the country for want of effective communication, and of that alone. It is well known that almost the whole of the manure produced in India is consumed as fuel. Now, consider the loss to any country in the world from its being deprived of manure, and especially the loss to the cotton districts of India at this critical moment. And this universal use of manure as fuel, not only for domestic purpose, but for factories, brick-making, &c., in the interior, is not in the least owing to the want of fuel of other kinds; there are wood and coal enough in India to supply all its wants for fuel a hundred times over. *It is solely from want of cheap transit!* Were the forests and coal districts laid open to the population generally by cheap transit, the whole of the manure would be applied to its legitimate use, the restoring of the land.

A very little consideration of this one point will bring forcibly before any one what India is losing from trusting the traffic to a single line of railway, carrying goods at from one penny to sixpence a ton per mile.

How can a country bowed down by such a burden as this one loss implies, hold its own with other lands?

And this is only a specimen. There are numbers of other items of traffic, the want of which is utterly weighing down the country.

When the unbounded treasures of India are put within reach, by cheap transit, of its own population and that of foreign countries, it is impossible to estimate what the wealth and prosperity of the country will rise to. I could almost wish the Emperor of the French were its ruler for

10 years. He would comprehend these things at a glance, and a very few years would see every valuable product of India put within reach of the population of every district and every port. The system of internal navigation, which he is with such wisdom carrying on at once throughout the length and breadth of France, would be immediately applied to the whole country between Peshawur and Cape Comorin, and between Kurrachee and Sadiya; nor would he lose a year in connecting the Burrampooter with the Yangtsi, and thus throwing open all India to all China.

The actual quantities of goods carried on an average on each line of railway in India, calculated from the goods receipts as given in the last Calcutta Engineer's journal for a few weeks, and allowing a mean rate of $1\frac{1}{2}d.$ * per ton per mile, are :—

	Tons.
Baroda Railway	15,000 per annum.
Eastern Bengal	52,000 „
East Indian	80,000 „
Indian Peninsula	100,000 „
Madras	58,000 „
Punjaub	6,000 „
Scinde	100,000 „

Thus these railways carry perhaps from one-quarter to one-fiftieth part of the *old traffic*, and that at prices the least possible below the old rates, but in many cases much above them, instead of providing for the carriage of the vast traffic *that has to be produced*, and which ought to be from 5 to 20 times the present. The traffic on the main line up the valley of the Ganges ought to be not less than 5,000,000 tons, while the railway carries 80,000 or one-sixtieth part of it, and this $1\frac{1}{2}$ per cent. carried at a charge

* The rates charged from $6\frac{1}{2}d.$ to $1d.$

that affords no saving worth mentioning, while the remaining $98\frac{1}{2}$ per cent. is just left as it was before all this heavy debt was incurred, most of the goods still not carried at all, and the remainder by the old means.

The same with the passengers: the actual numbers carried on an average all along the different lines, calculated from the weekly receipts, and allowing a mean rate of $2\frac{1}{2}$ pice on a line on which the lowest charge is 2 pice, and $3\frac{1}{2}$ on those on which the lowest is 3 pice, are as follows:—

Baroda Line	840 per day.
Eastern Bengal	830 „
East Indian	720 „
Indian Peninsula	1080 „
Madras	600 „
Scinde	250 „
Lahore	700 „

Now, if we take the East Indian line as one specimen, we may be sure that 720 is not one-fifth of the present travellers on that line, and so with the others, and not one-twentieth of those who would travel if the rates charged were such as they could afford, and such as they are where water-carriage exists—viz., from one-sixteenth to one-twelfth of a penny per mile.

So that the railways as utterly fail to carry the great mass of the people as they do that of the goods.

But what can be more absurd than for the different parties concerned in those railways to be quarrelling and throwing the blame upon one another because they don't do what it is as impossible for them to do as for a donkey to carry the load of an elephant?

The actual work done by the Bengal Railway is 80,000

tons a year, at about three-halfpence, and 720 passengers a day at about $3\frac{1}{2}$ pice, or under one halfpenny.

What a main communication on that line is wanted to carry is about 5,000,000 tons a year at one-eighth of a penny per mile, and 20,000 passengers per day at one-twelfth of a penny. These are the kind of statements that are required to show whether the railways are really meeting the wants of the country or not, and in connexion with the statements of the members of the Bombay Chamber of Commerce, they show their complete failure to meet the wants of the country; so that there can be no mistake about it.

If it is asked—but what have these details to do with the Ganges Canal? I answer, everything. First, because they show that there is the same effort throughout on the part of my opponents to persuade themselves and others that works which really have utterly failed have not done so; or else that the failure is owing to projection or execution, when it is really owing to the nature of the works, as in railways; or that it is owing to the nature of the works, when it is solely owing to the projection and execution, as in the Ganges Canal. No projection or execution could possibly enable a single railway (or even a double one) to carry one-tenth part of what is wanted, or to charge for transit less than 10 times the price that is required to enable India to flourish; and, on the other hand, nothing but monstrously false projection and execution could have prevented irrigation and navigation from being enormously profitable in the Doab.

And secondly, this discussion is directly to the point, because it shows in the most distinct manner the tremendous mistake made by the Engineers of the Canal in treating the transit as a matter of so little importance, that

it was worth while indeed to make a show of it by building locks, and at the end pairs of locks, &c., but that it was quite unworthy of that expense and that attention which were required to make it really effective. *Water transit in India is an absolute necessity*, as it is in America and France, and even, to a less extent, in proportion to its size, in England; nothing but water can carry the quantity, or at the charge, that any country, and especially a great Continental country, really requires.

We cannot indeed be so much surprised at the Civil authorities being so entirely mistaken on such a point, when the professional officers are so profoundly ignorant of the fundamental principles of their profession as to suppose that railways can carry the millions of tons and passengers that have to be provided for, and that it is a very insignificant matter whether hundreds of miles of canal were made effectively navigable or not.

Of the absolute necessity of water transit, we have, besides the enormous sums lately expended by the Americans on the Erie Canal since the construction of railways, a strong proof in the following account of what is doing in France at this moment, as stated in the *Times* of the 29th December, which is as follows:—

Letter in the Times, dated Paris, Dec. 28th.—"The following are some of the public works of which the utility was declared by the imperial decree, and which are at present in progress of execution:—The works undertaken on the river Seine consist in the construction of twelve dams between Paris and Montereau, to secure a depth of five feet of water and a regular navigation between Paris and Rouen, and likewise between Paris and the mouth of the Oise. There remains the part of the river between Rouen and Quillebeauf to

“ be improved and the breakwater to be strengthened.
 “ Nine dams are to be constructed on the river Marne, and
 “ two cuttings are being made so as to secure a continuous
 “ navigation between Paris and Strasbourg. Twelve dams
 “ with sluice-gates are to be constructed on the Yonne, in
 “ order to secure five feet of water for boats passing from
 “ Paris to Lyons. Seven of the most dangerous passages
 “ between Lyons and Arles, on the Rhone ; and it is pro-
 “ posed to complete these works by raising the water six
 “ feet between Arles and the canal of St. Louis, to facili-
 “ tate the navigation to the mouths of the river.

“ The passage from the Bec D’Ambes, and from Bassens
 “ on the Garonne, is at present being improved, so that
 “ foreign ships may navigate the river.

“ Submersible breakwaters are being tried by the Italian
 “ Government on the left bank of the Var ; quays are being
 “ constructed on the Nive, and great improvements are
 “ being made at the port of Thonon and Evien, on Lake
 “ Lemman. The Sarthe is being made navigable between
 “ Angers and Le Mans ; and a similar improvement is
 “ being made between Angers and Laval, on the Mayenne ;
 “ and quays and bridges have been constructed on the
 “ Villaine in its passage to Rennes.

“ There are likewise various improvements going forward
 “ on the rivers Adour, Arve, Baise, Bontonne, Charente,
 “ Deule, Drouse, Loir, Lot, Lys, Mayenne, Meuse, Scarpe,
 “ and Vire. There are other public works admitted to be
 “ necessary, but for which a decree has not yet been issued,
 “ such as the construction of four dams and sluices on the
 “ Saone, between Lyons and Chalons, to secure a constant
 “ depth of five feet in the river which forms part of the
 “ great navigable line from Paris to Lyons, the completion
 “ of the canal begun in the year 1835 on the Lot ; the
 “ canal on the Moselle, between Fronard and Metz, and
 “ various improvements demanded by merchants on the
 “ Allier, the Charente, the Dordogne, and the Tarn.

“ There are other works long since begun, and only now

“ about to be finished—such as the canal from La Rochelle
 “ to Marans, commenced in 1805, which will unite the
 “ port of La Rochelle with La Seure near Marans ; the
 “ canal from the coal mines of La Sarre, which will
 “ cause a great fall in the price of coals in the valley of
 “ Sarrebuck and in the manufacturing districts of Alsace
 “ and Champagne ; the canal of Roubaix, which will form
 “ a junction of the Deule and Scheldt—the lateral canal of
 “ the Marne between Vitry and St. Dizier, undertaken for
 “ the advantage of the ironmasters in the Haute-Marne ;
 “ the extension of the canal on the Upper Seine, between
 “ Troyes and the Maisons-Blanches, being a distance of
 “ twenty-five miles, and other works to maintain a sufficient
 “ quantity of water in the canals of the centre ; the Haute-
 “ Deule, from Nantes to Brest ; from Blanet, Ile et
 “ Rance ; the Ardonnes, from Arles to Boue ; and a canal
 “ from the Rhone to the Rhine.”

This includes a vast extension and improvement of the internal navigation of France, and will, with the old works, form a complete system of internal navigation with 5 feet of water or more throughout the empire, connecting all the great river-basins with each other, and with the Scheldt and Rhone. This is after a full trial of the system of railways, and in face of the strongest possible bias in favour of the latter. There can be no doubt that the same thing must take place in England, notwithstanding the tremendous strength of railway interest and railway prejudice. All these great lines in France have railways running parallel to them, as the Erie Canal has. I must here take notice of the absurd fancy, that canals are not fitted for speedy transit. This is one of those imaginations that so often control the proceedings of nations for a long period, without any one ever giving the subject the five minutes' considera-

tion that would be sufficient to show that it is nothing but fancy. There are steamers running at this moment at from 20 to 25 miles an hour, on light drafts of water; therefore what is to prevent canals being navigated at high speed? Some suppose that the locks will cause so much delay; but this is only because the old locks in this country were made with such small sluices that they took several minutes to fill and empty; and there is not the least necessity for this. It is only to make the opening large, when the lock may be filled in a minute, and it need not cause the detention of a boat longer than a train is detained at a small station.

There are parts of England that could be traversed by canals worked at any speed, and at charges about $\frac{1}{4}$ or $\frac{1}{8}$ of that of railways, and in India this could be done at a cost of not more than $\frac{1}{8}$ of the outlay on railways. It is curious to observe France finding out this mistake—the fancy that railways will supply the place of canals—before England.

In England itself, the actual state of things respecting the heavy traffic, seems to be universally misapprehended by the general public.

The principal traffic is still carried by water; by far the greater part of it by the coast and rivers, though large quantities are still carried by the old canals, imperfect as they are; very narrow and shallow, very winding, with very small locks, which still take nearly two minutes to fill or empty, and quite unfitted for steam-power. As soon as the country wakes from its railway mania, as France and America have begun to do, it will discover that, even with its insular position, and consequently vast extent of coast and river navigation in proportion to its area, it cannot do without internal steam-boat navigation, as France and America have learnt, after

many years' trial of railways. And no doubt, when once some bold man, in the face of ridicule, improves one of our old canals for large boats, steam-power, and good speed, there will be the same conversion of opinion in England, as there was in the United States, on seeing the success of the Erie Canal.

But if France and America, with their complete network of double railways, after so many years of trial, have been compelled to spend millions upon waterways, how much more must India, with its ridiculous threads of single railways in such a vast country, require a complete system of water transit, on the most extensive scale, so as to provide for a traffic far beyond anything that has yet been thought of. If we were to take away from the American States the Erie and other canals, the lakes, and the Mississippi and other rivers, they would instantly collapse, in spite of all their energy and all their double railways. If they had to carry all their produce at from $1\frac{1}{2}d.$ to $3d.$ a ton a mile, *nineteen-twentieths of their traffic would instantly be stopped*, and the whole country would be paralysed; they would become a mere skeleton of what they are. And even of the remaining things that would bear the cost, the railways could not carry one quarter of the quantity with passengers.

Now, I repeat, is it not wonderful that not one man connected with the railways, either in the Government service or out of it, either in India or England, could be found, who had the nerve determinately to force upon the authorities the fact that a single railway (or even a double one) could not carry one-twentieth part of the goods and passengers that had to be provided for, nor at less than ten times the cost of carriage that was absolutely essential to the well-being of the country? For want of one such faith-

ful man, India has been kept 15 or 20 years longer without this essential; and not only so, but that time has been employed in raising up a tremendous additional hindrance to the construction of the only works that can supply the wants of the country.

I have spoken of the main cause of failure of the railways, being not in the projection, but really in the nature of the works themselves, as not being the kind of works that the country requires, in its present circumstances, now proved by two facts: first, their requiring a great increase of taxation to support them, while works of irrigation and navigation are actually not merely supporting themselves, but greatly relieving the revenues, (certainly much more than half a million a year, now realized from them in only three districts, Tanjore, Godavery, and Kistna, one-fortieth of the districts of India,) and enriching the whole population.

I urge that this is the true test in general of works of public improvement, that if they have so little effect upon the material prosperity of the country, *that they cannot support themselves by direct returns*, they are not suited to the circumstances of the country.

Secondly, the fact that one of the principal lines is declared by the Chamber of Commerce of Bombay to have utterly failed, even to convey one trifling article of traffic, not one-fiftieth part of what ought to be conveyed on that line. But I must add here, that there has been the same utter failure of projection in some of the lines at least as there has been in the Ganges Canal.

I give here extracts from a most sensible and useful pamphlet by Colonel Showers, showing the mode of projection of the Madras line.

Extract from Colonel Mhowers' Pamphlet.—"For the first
 " two or three miles from Madras the railway circles round
 " the suburbs to the first station, Perambore, thence to Salem
 " station, a distance of upwards of 200 miles, and taking nine
 " hours. *The country on each side of the rail is a barren*
 " *waste, unrelieved, except at rare intervals, by a patch of*
 " *cultivation or signs of human habitation, save occasional*
 " *clusters of conical-shaped huts, resembling ant-hills, de-*
 " *noting the natives to be in the most primitive state,*
 " *guided alone by the instinct of the inferior creatures.*
 " *The rail does not touch a single city, nor even considerable*
 " *village, throughout its entire length. The object of the*
 " *projection of such a line it is difficult to understand.*
 " We have all heard of the faith, pure and simple, of the
 " philosopher, who, in looking at the map of the world,
 " and observing the chief cities to be situated on rivers,
 " remarkèd on the bountiful dispensation of Providence
 " which had caused the rivers to flow through the chief
 " cities of the earth for the convenience of the inhabitants.
 " How much more incumbent was it, then, on the official
 " Providence, that watches over the sublunary affairs of
 " this heathen land, to take thought that the civilizing
 " stream of the rail should pass through and enlighten the
 " chief cities of the benighted !"

Speaking of the station twenty-four miles from the
 Neilgherries, he says :—

"Seeing that in pursuance of the *inscrutable policy*,
 " which throughout the line has carried the rail along at
 " a distance from all the towns, a railway hotel was an
 " obvious feature of the enterprise. . . . Beypore, the
 " ocean terminus of the railway on the West ! It is diffi-
 " cult to describe the sense of disappointment on arriving
 " on such a terminus after traversing the entire breadth
 " of the Continent, upwards of 400 miles from the sea on
 " the East. What do we find ? An insignificant fishing

“ village buried in the dense cocoa-nut and jack-tree forest,
 “ which fringes the sea-beach all along the sea-coast here-
 “ abouts ; a small river falling into the sea at this point,
 “ but the entrance to it from seaward hopelessly blocked
 “ by a bar eight or nine feet in depth, and over which
 “ a dangerous surf is perpetually breaking ; a couple of
 “ patimars lazily lying outside the bar ; and looking north-
 “ wards up the coast, two ships loom in the offing, off
 “ Calicut, that port being seven miles distant, the said
 “ ships being only visible from Beypore, because lying from
 “ two-and-a-half to three miles out in the roads on account
 “ of the shallowness of the whole Malabar coast at this
 “ part. *The railway may thus literally be said to end—*
 “ *nowhere* ; the grand railway station which is building,
 “ notwithstanding. For Beypore possesses no single quali-
 “ fication for a port of embarkation and disembarkation
 “ for either passengers or merchandize.

“ The sole feature of the place which could have afforded
 “ even a plausible pretext for constituting Beypore the
 “ ocean terminus, is the fact of the small river of that name
 “ falling into the sea there ; and had it been one of deep
 “ and unobstructed channel, accessible at all seasons to ocean
 “ ships, the measure would have been intelligible, inasmuch
 “ as affording promise of utility in future. If the P. and O.
 “ ships could enter the Beypore river, or were there even a
 “ roadstead outside where they could lie at anchor at all
 “ seasons, the advantage of this short cut to Madras and
 “ Calcutta would soon have called into existence quays and
 “ wharves, and the usual offices of a port. But when the
 “ actual features of the case are considered, the impracti-
 “ cable and dangerous bar which effectually closes the river
 “ to ships, and even to boats, except at much hazard of
 “ swamping ; and further, the shallowness of the coast,
 “ which obliges ships to lie from one-and-a-half to three
 “ miles out in the open roadstead, subject to be thrown on a
 “ dead lee shore in the S.W. monsoon or any westerly gale ;

“ when these utter, absolute, and irremediable disqualifications of Beypore as a port are taken into consideration, what are we to think of the local railway management which could have allowed such a project to be carried out manifestly without due inquiry into the capabilities of the place ? ”

Every word of this is true ; it is a simple account of the line, and gives a perfectly correct view of the case. So far as was possible, the population both urban and rural is carefully avoided ; indeed, one could hardly have imagined that in so populous a country as the Carnatic, a line could have been found so far from even a rural population. There are between the two coasts, besides a very dense agricultural population over a great part of this tract of country, the following cities and cantonments, containing each from 20,000 to 80,000 inhabitants, viz., the Mount, Palaveram, Poonamalee, Wallajabad, Conjeveram, Wallah-jamuggur, (the grand seat of trade, and entrepôt of the North Carnatic,) Arcot, Vellore, Salem, Bowani, Coimbatore, and Palghaut—twelve important places, besides numerous others, not one of which does the railway touch, and after reaching the Western Coast, it runs along it twenty miles needlessly, to end *nowhere* !

There is thus on this line as monstrously false engineering as on the Ganges Canal. The cost of this work has been £11,200 per mile (including only a very small quantity of rolling stock), besides accumulated interest at 20 per cent., or in all £13,500 a mile (besides cost of land). For the 400 miles its cost is about 6 millions.

Its work at present is—

Passengers per day 600, at one-fourth of a penny for 3rd class.

Goods per annum, 58,000¹/₂ tons, at one penny for the lowest class.

What this line of country requires to have carried is probably at least :

Goods, 500,000 tons per annum, at one-eighth of a penny.

Passengers, 5000 per day, at one-sixteenth of a penny.

It may thus be carrying one-tenth of what is required, and at from 4 to 12 times the charge that is consistent with the healthy development of the traffic of the country.

Now, I am well acquainted with the whole country between the two coasts, and am sure that a first-class steamboat canal, 30 or 40 yards broad, and 8 or 10 feet deep, with locks for boats of 300 tons to fill or empty in a minute, capable of being worked by steamers at 20 miles an hour, could have been constructed for £4000 a mile, probably for less at that time, or much less than one-third of what the railway has cost, thus saving 4 millions sterling. But as irrigation would be combined with navigation, which alone would pay its interest five times over, *the communication would in fact have been obtained for nothing*; and it would have done what the railway never can possibly do—carry the required traffic of the country at available rates, and even passengers at the same speed as the railway. And this work must still be executed as if no railway existed.

The net receipts on the railway, by the last published Report, were £48,000, or less than 1 per cent. on the real capital sunk, *without any allowance for depreciation, which must be much more than 1 per cent.*, so that the railway is certainly not paying its expenses,* and the whole interest,

* Compare this with the opinion of the consulting engineer of this railway a few years ago :—“ I have shown that there is every probability of these roads paying, when they shall have

£300,000 a year, besides loss in working, &c., is collected from the general population of Madras on salt or income-tax.

The other branch of the Madras Railway to the North West will be far worse, for the whole country is far poorer and less productive for 500 miles.

The six millions that this railway has cost might thus have certainly given us, instead of 400 miles of ineffectual land carriage, fully 2000 miles of perfectly effective first-class water carriage, with millions of acres of irrigation into the bargain, and with transit even at the same speed as the railway. Compare these facts and arguments with another of the sayings of one of the railway engineers a few years ago,—“Consider it as you will, the railway is the most valuable and efficient instrument of the two.” It was by such things as these that every effort was made to confirm the Government in the false view they had formed of railways in India, by those whose duty it was as professional men to point out the utter absurdity of supposing that railways could do the work that India required; but India is paying for the false ideas of such men in millions of money lost, in millions of lives endangered by famine, in millions of subjects irritated by needless and oppressive taxes, in hundreds of thousands of bales of cotton rotting in the ground, in the discontent of the leading mercantile men, in the misappropriation of millions of tons of manure to the purposes of fuel, instead of restoring the land, and in a variety of other evils which cannot be enumerated.

One of these men said to me, “Such a move was the making of me,” meaning that it had led to his holding a fine
 “become sufficiently extended, and shall have had time to take
 “over all present traffic and to create more work, both of which
 “processes are now going on together.”

appointment. What can be expected of men who are thinking of what will be the "making of themselves" instead of what is their duty, and what will be the making of India?

Such a man of course, in writing his report, is thinking really all the time of what he can write with safety to himself, not what is the real truth of the case, and what will consequently be for the good of India; though probably he is not the least sensible that he is under the influence of such a bias. His real thought is not—what is the truth? but what do my superiors think of the matter? so that what I write may make them think I am a very sensible and judicious man, in consequence of my agreement with them. But the duty of a professional man is not to confirm his non-professional superiors in the false and crude notions which they must necessarily have on subjects to which they could not possibly give the time and attention required to understand them, but to try as far as possible to set them right, by giving them the results of the undivided attention which he has given to them, and the long experience he has had in them.

In doing this, we must always run the risk of giving great offence; of making great men say, "Why, in so saying, you make out that I don't understand the subject," and look out for some more convenient man who will not disturb their preconceived notions.

But we must either do this or sell India for an income of 1000 or 2000 rupees a month for ourselves. It is impossible but that rulers must have comparatively crude notions on professional subjects, because they have a thousand things to attend to, and they are under a necessity of taking superficial views of such things. How should a governor, for instance, know how much a single railway

will carry? See if there is one single man in civil authority at this moment who will answer this question, which yet lies at the very foundation of the whole subject of transit. Ask him, again, on a main line through such a tract of country, ought the traffic to be 50,000 tons a year, or 5,000,000? He has not the remotest idea; you might as well ask him to translate a Chinese symbol.

How can he have? These are just like other things; they are not known by instinct, they must be learnt; and the authorities have a right to expect that the professional men will search out such matters as belong to their profession, and will give them real information about which they have satisfied themselves.

But when professional men utterly fail either to acquaint themselves with the fundamental points of their profession, or else boldly and conscientiously to persist in pressing the truth on their superiors, for fear of their own reputation and promotion, when on either of these accounts they will tell them it is well to spend £200,000 or £300,000 on locks, &c., but that it is a matter of very little consequence whether or no 500 miles of fertile and densely-populated country 1000 miles from a port have effective means of sending their produce to market, or of supplying themselves with fuel, building materials, and the products of distant countries and provinces, and even of food in time of famine, what must be the consequence but poverty, ruin, famine, discontent, rebellion, "degradation in the eyes of our native fellow subjects," &c.?

The man in civil authority sees a railway carrying a great number of passengers, and of tons of goods, and not having time to inquire into the matter, he never finds out that it is the means he does not see, that is doing the

great work of the country in the way of transit, the coast, the rivers, and the canal. He sees the few thousands that are carried; it never occurs to him that the question is not about them at all, but about the ten or it may be fifty times that number that are not moved, solely for want of sufficiently cheap carriage; goods which are immovable, and must remain where they are, almost or quite valueless, because they cannot be taken to where they are valuable and saleable.

✓ Now it is for the very purpose of providing ourselves with sound information and opinions that professional men are paid, and upon their faithfully and at whatever personal risk doing their duty in this respect, depends, whether the country prospers or not, whether, for instance, seventy millions and fifteen years are expended in giving a country 4000 miles of communication utterly incapable of doing what the country needs, or the same sum on 20,000 miles of another kind perfectly suited to its wants, and which will at the same time incalculably increase its produce and secure it against famine as far as possible. This is not requiring too much of men. An officer in the field does not think of what he can do with safety to his own life, but of what his duty requires him to do at the risk of that life.

I must also notice in reviewing this discussion, the different grounds which Sir Proby and I have taken.

He has made only a personal affair of it; my sole object has been to treat a great public question on public grounds. Seen through Sir Proby's personal spectacles, everything I say is boasting, or not complimentary, and so on. I am neither boasting, nor complimenting, nor blaming, but simply trying to show the true state of the case in respect of irrigation and navigation.

To the millions of England and India, it does not signify one straw whether we personally have made mistakes or not; but whether the latter shall be preserved from famine and favoured with abundant harvests and cheap carriage, and whether the former shall have an unbounded mine of raw produce, and an unbounded market for her manufactures, concerns every man, woman, and child in both countries.

Between 1850 and 1861, the British imports into India increased from seven to twenty-one millions; and if all the income of all the districts of India were increased seven-fold, as that of the Godavery will certainly be when the distribution of the water is completed, I should think it extremely probable that they would increase rapidly to one hundred millions. And at this moment this depends more than anything upon the correct answer to the question—Has the failure of the North West works been owing to immovable obstacles to irrigation in India, or is it solely owing to mistakes, fundamental ones, in the projection? Of course in discussing this great public question, personal feelings cannot but be interfered with.

I regret extremely that they must; and if anybody could tell me how I could bring clearly before the public the causes of the success of the irrigation works of Madras, and of the failure of those in Bengal, without distressing any individual, or appearing to boast, I should be very glad. To me it seems impossible.

I most fully allow the matter might be much more delicately handled, without any compromise of truth, by many men; but I have endeavoured not needlessly to annoy anybody.

Nothing can be more certain than that if the Godavery

works had been constructed on the principles of the Ganges Canal, the result would have been exactly similar. Had we gone up into the hill-tract to fetch the water from hundreds of miles above the level of the mass of the Delta, for the sake of an insignificant quantity of land on a higher level ; had we left the work without a permanent weir that would give an effective control of the water, so that we should have found ourselves without it in the midst of a famine ;* had we delayed our distribution works whilst we built hundreds of bridges ; had we expended our time and

* "In addition to the usual boulder bunds thrown up annually
 " in the river Ganges for the maintenance of the canal-supply,
 " a third bund was found necessary to hold up the leakage
 " passing through Nos. 1 and 2, and was constructed immediately
 " under the crib-work, unbedded in the river last year to prevent the hollow which had formed there working back, &c."
 " The head bunds were completed on the 13th January, 1863,
 " but on the 25th of the same month a flood came down" (in the very midst of the cultivating season) "which breached
 " No. 2 bund in four places, and carried away a small portion
 " of the right flank of No. 3. Bund No. 1 stood intact, though
 " the flood stood two feet above it. Notwithstanding this flood,
 " the supply required for the canal *being small*, was uniformly
 " kept up till the 21st May, 1863, when, owing to the melting
 " of the snow in the hills, the Ganges rose. No. 1 Beemgadale
 " bund gave way at about 200 feet from the right bank of
 " the river, and continued breaking till the end of the month,
 " when the breach was widened to 130 feet ; No. 2 bund had by
 " that time almost quite disappeared, and though the volume of
 " water passing down the river was very great, and the Hurdwar
 " bund remained intact, the supply of the canal fell to 5 ft. 9 in.
 " at Roorhee.

" Mr. Sogin was unable to increase this supply till the rains
 " set in ; for, with such a vast body of water passing through the

money in making deep excavations in order to leave the water below the level at which it was wanted; had we, instead of making use of any old channels that we could turn to account for the time, waited till excavated canals had been made everywhere; had we executed the navigation by halves, building bridges at every three miles, without towing-paths under the arches and too low for loaded boats,* making the boats go round, instead of the water, giving such a current that boats could hardly stem it, &c., &c., so that the traffic would be paralysed; had we built our weirs of brick when stone was to be had, leaving them much more liable to injury;† had we carried on these works upon those

“bunds, it was impossible to repair them, as they could not be “approached even with a boat.”—*Canal Report for 1863*. This account is surely sufficient to show the desperate mistake of leaving such a work, upon which millions of lives were liable to be dependent, subject to such contingencies for want of an addition to the cost of 2 per cent.

* “Although there has been abundance of cotton to send “down the country, very few people availed themselves of the “transport afforded by the canals, in consequence of some of “the bridges being so low that they were unable to load them “sufficiently to make it remunerative.”—*Canal Report for 1862-3*.

† “Considerable wearing away of the bricks of the ogees of “the falls is observed, and portions of the floorings also have “given way; the grooves, too, are more or less injured.” “At the “Azafnuggur falls . . . a portion of the Chamber No. 4, which “had given way, was repaired; but as the unprotected green “masonry failed, the repair had to be renewed and covered “with planking, bolted down to the flooring.” “The Mynud- “pore Falls which, from the opening of the canal, have been “continually giving way, were in a most dangerous state, and “necessitated repairs which were executed between the 15th

principles, nothing can be more evident, even to non-professional men, than that we should have spent two millions with no adequate returns to this day, instead of paying our own way from the very first, and enabling the district to pay into the treasury three times the whole cost of the works before the whole Delta is irrigated! Had Colonel Smith not been unfortunately prejudiced, but had condescended to discuss the matter with us, it is impossible that he could have seen such results and have learnt nothing from it. The fact was, he was brought up in a false school of engineering, in which the real interests of the country were sacrificed to appearances, the substance to the shadow, the major to the minor, and in which things were done by halves. First, the real interests of the country were sacrificed to appearances: a vast excavation with innumerable bridges, but no secure supply of water, and only a trifling distribution of the water to the land, 18 or 20 years after the works had been on hand. Secondly, the substance to the shadow: the preservation of the people from famine by

“October, 1862, and the 18th January, 1863. The repairs
 “consisted chiefly in rebuilding the damaged portions of brick
 “masonry, and covering the floorings with either blocks of quartz
 “zoze or planking.” On the 13th February, 1863, for the first time
 “since the canal was opened, the flooring of No. 2 chamber of the
 “Jowly Falls gave way immediately below the ogee, and the
 “breaking up of one chamber after the other followed in rapid
 “succession, causing considerable anxiety. Partial repairs with
 “brickwork laid in cement, manufactured after Pasley’s method,
 “and loose Delhi stone, have been made, which enabled us to
 “carry the supply throughout the season.” It is evident that all
 this loss and much greater risk was the consequence of trusting
 to brick masonry. The canal was closed for nearly three months
 in the height of the dry season cultivation.

irrigating the land and conveying food neglected, while they were saved from the inconvenience of ferries by many bridges. Third, The major to the minor: £1,000,000 expended to bring the water from above the only difficult country in order to supply a little patch of perhaps 100,000 acres on a high level, while ten millions of acres were available below a level which was clear of all difficulties. Fourth, things done by halves: locks provided for navigation, but too strong a current, too low bridges without towing-paths, dangerous weirs in the direct line of the navigation, narrow winding channels to the locks, &c., &c.*

It must indeed be acknowledged that all these false principles combined would have failed entirely to counteract the wonderful natural advantages of this tract, certainly one of the most favourable tracts in the world, if they had not been crowned with as false principles of finance, which,

* The history of this Ganges Canal puts in a very strong light one plain advantage in having these works executed by private companies. Shareholders must know whether their dividends are nothing or 40 per cent., and no reports, however clever, can possibly persuade them that there is nothing amiss in a work in which two millions have been spent in 20 years without a dividend, when various perfectly unbiassed authorities unite to testify that similar works are actually paying from 40 to 100 per cent. It seems to me pretty certain that one clever fellow would be found, among either the shareholders or directors, who would under these circumstances suggest that the opinions of some of the Engineers of the successful works should be obtained, that it might be seen whether they could account for the failure, and suggest a remedy. I think they would hardly be content to go on year after year, for an indefinite time, contented with the reports of their own Engineers, that, in spite of appearances, everything was conducted in the best possible manner.

when millions had been spent on the main works, would not allow the small sums required for the distribution of the water, which has been lingering on for so many years. Fifty millions have been spent on works which could not pay interest, or prevent famine; while £200,000 or £300,000 has been withheld, which was wanted to complete these incalculably important works, to enable them to pay their interest, to save the lives of hundreds of thousands of people, and to convey more goods and passengers on this one line than all the railways in India can carry.

To return. Neither the failure of his own principles of construction, nor the success of other principles, could bring Colonel Smith even to say to us, "But I should like to hear what you yourselves say is the cause of this success." It seems very remarkable that there was not at that time in the Government of India, or in that of the North West, one person who had the wit to put this awkward question to Colonel Smith:—"But if all those works are carried out upon wrong principles of operation, and yours upon right ones, how do you account for it that those have had such unprecedented results while yours have so remarkably failed?" And if this question had puzzled him, have then said—"Well, if you cannot answer this question, we will see if the Madras officers can."

Perhaps, however, it was as well that the full discussion of it was deferred till now, when the whole case is so developed, that there can be no possible doubt about it on the part of those who are not committed on the wrong side.

The fundamental point in the whole subject is the prodigious difference between the necessary *cost* of water when obtained by works on a large scale, and its *value* when

on the Godavery have cost up to this time £420,000, besides repairs, and about two-thirds of the land are watered. When about £500,000 has been spent, the water will be distributed over about 1,200,000 acres, which is 8s. 4d. an acre, and at 10 per cent. for interest and repairs, 10d. a year per acre. At the present prices the difference in a rice-crop by irrigation is about £3, and it is now said that 100 pounds of cotton per acre is gained by irrigation; which, for the tropical cotton, which is short in staple, would be worth now on the spot about £6 (at 1s. 3d. the pound); but this is besides free navigation and a second crop.

In such a case, economy consists not in saving 20 or 30 per cent. of the cost of the works by executing them with great deliberation, but in saving time and getting the water upon the land without losing a year. Had the Ganges works been executed on these principles, it is most certain that land could have been watered the very first year, and irrigation with effective navigation have been extended throughout the Doab long before this down to Allahabad,*

* Among the strange delusions that were indulged in with respect to these works, one was that the river navigation could not be injured by them; and papers were written to prove to demonstration, that after $\frac{3}{4}$ of a million of cubic yards an hour were taken out of the river, there would be just as much left in it as there was before. One proof was that the Jumna Canals were shut for a short time (not long enough to show the full effect), and when it raised the water $1\frac{1}{4}$ feet—the previous depth being 2 or 3 feet—it was exultingly said, “Didn’t we say so?” And this was given as conclusive that the navigation would *not* be injured. It could not of course make any difference to a boat drawing 3 feet whether there was 2 feet or $3\frac{1}{4}$ feet of water! It seems incredible that such things should

with no issue of money from the Treasury excepting just to start the works. There is nothing whatever in the two tracts to make any essential difference in the results as respects either time or money. And the Dooab is decidedly the easier tract of the two to irrigate.

Now I speak with the utmost confidence when I say that these works might have been so planned as for a million sterling to have provided a perfect navigation from Meerut to Allahabad, and to have irrigated two million acres at least, besides giving hundreds of miles of navigation on the branch canals, and that such works like ours on the Godavery should have paid from the very first. Upon our principles, we should have begun with the construction of a permanent dam below the Soani, which, for so small a river only (one-sixth the volume of the Godavery) need not have taken above two years, and we should have cut, the be. In a late Delhi Gazette it is stated that "the quantity of water drawn from the rivers by the canals has seriously affected the navigation of the Indus." What a wonderful discovery! who could have imagined it? Think of a man emptying half the water out of a bucket, and then finding there was not so much in it as there was before. Of course nothing but actual experiment could convince any one of such a phenomenon.

The stoppage of the canal, therefore, at Cawnpore was a terrible evil. The injury done to the river navigation by diverting so large a portion of the water from it (the quantity thrown into the canal was about half of the usual cold season stream at Cawnpore), when it was very imperfectly navigable before, made it imperative that canal navigation should be substituted for it between Cawnpore and Allahabad.

The water was indeed a serious loss to the navigation even below the latter city; but after the addition of the Soane and the Tonse, the difference made by the abstraction of the canal water was not so great as above.

first season, a moderate canal from it, 30 or 40 miles in length, so as to bring the water out at once on to the table land, and irrigate the first year, making temporary dams till the permanent one was completed. We should at the same time have begun at the main line of the canal throughout its whole length to Allahabad, cutting only what was necessary to form the two banks, and constructing the locks and waste weirs so as to bring the navigation into operation in the shortest possible time, that the natives might learn to use the canal, leaving it toll free, as we have in the Godavery. The second and following years the irrigation might have been rapidly extended. In this way I am certain that the whole work might have been carried out with the same success, as the Godavery works, that long before this the whole Dooab might have been both irrigated and pervaded by a completely effective system of navigation, suited both for fast steamers and for the heaviest cargo boats, and that we should have seen the same increase of revenue, of traffic, of exports, and of income of the landowners and labourers as we have seen in Madras. In fact, there was to be expected a much more rapid development of the Dooab, for there much had already been done in the way of roads, &c., to raise the landowners, whereas in Rajahmundry nothing whatever had been done, and the people were in such a depressed state, so sunk in poverty and helplessness, and so overwhelmed with debt, that they were in a far less favourable position to take advantage of the new openings.

I must conclude by expressing my unqualified satisfaction at this discussion. I feel confident that the irritation produced by it will be quite temporary, but that the results of it will eventually be extremely important. People in

any way concerned in the well-being of India have now before them both sides of a question of incalculable importance to that part of the empire (and to this too), and those who are not entirely committed to one side will be able from these materials to form a sound judgment of the main points of the question. The publicly declared utter failure of the Bombay Railway at this time to meet the demands of trade, where there was not, as in Bengal, water transit to fall back upon, will also greatly help to put the matter in its true light.

I cannot promise, as Sir Proby has done, that these shall be my last words on the subject,—I should rather promise to hold myself in readiness to do my best still to clear up any remaining doubts that may be started on the subject.

APPENDIX.

I HAVE just obtained copies of the *Calcutta Government Gazette*, containing various papers on the Ganges Canal. In all these there is the fullest acknowledgment of great essential defects in the project, and the object of them is mainly to discuss the remaining question, viz., what works are required to “*remodel*” the Canal. They contain rough estimates of no less than £400,000 and £560,000 for works on two different plans for this purpose. The papers consist of reports by the officer lately in charge of the Canal, by a committee of Bengal Engineer officers appointed to examine this question, by an officer afterwards set apart to prepare the plans and estimates, and also one by Sir Proby Cautley recommending an entirely new Canal to be cut parallel with the present one, from which it is to branch off at 20 miles below its head, in order that the water may be divided between the two, as a remedy for the injury which is at present done to the bed and sides of the Canal, and to the masonry works.

There is therefore no longer any question about essential defects of projection; the subject is now confined to these two points: What are the remedies to be applied?—and consequently (which is the essential point at this moment), is the mode of “*remodelling*” the Canal to be settled solely by the officers connected with the present failure, or is the matter to be fairly and openly discussed, so that the opinions of other men, and especially those who have had experience in successful works, may be clearly brought forward?

I must here plainly state my own opinion on the plans proposed in these papers, for the “remodelling” of the Canal, that they are all based upon as utterly false principles of hydraulic engineering in India as the original project, and that, if they are carried out, another half million—more probably a million—will be expended, and 5 or 10 years more lost, without attaining the desired object of putting the project into an effective state. And is it not perfectly natural to suppose that it would be so? All the officers who have yet given an opinion have been brought up in this false school, and it must necessarily be that, before they can plan correct works, they must be set right in fundamental principles. Surely the smallest degree of common sense requires, that in such a case, the opinions of others should be heard, and especially when there are those who have been employed for many years in precisely similar works which have been not merely no failures, but extraordinary successes.

It is very remarkable that in the very same gazette which contains the Resolution of the Government of India on this subject, there is given an official return of the results of the great Hydraulic Works in Madras, showing net profits as follows, for 1862–3 :—

	Per cent., per annum.
Upper Colleroon Anicut	270
Lower “ “ in Tanjore . .	8 $\frac{3}{4}$
“ “ “ in S. Arcot .	346
Kistnah Anicut	15
Godavery “ 	47

And the total of profits, “after paying 4 per cent. interest, on capital,” as follows :—

Upper Colleroon Anicut	£1,168,180
Lower “ “ in S. Arcot	643,419
Kistnah “ 	57,733
Godavery “ 	949,839
Total	<u>£2,819,171,</u>

on a total cost of £564,651 ; so that, on an average, these four great works have paid into the treasury after deducting repairs, interest on capital, &c., about 5 times their cost, though two of them are yet unfinished, and one, the Kistnah, has not yet been completed to the extent of watering one-fourth of the land commanded by the Anicut !

Is it not most remarkable that neither in the papers of the local engineers now published, nor even in the resolutions of the Government of India, is any allusion made to this, by far the most important fact connected with the question of the failure of the Ganges Canal ? In the whole of their documents this great fact, so calculated entirely to remove the despondency caused by that failure, is wholly ignored, and the papers are all written as if the writers could only guess and hope about the results of irrigation in India being profitable.

It is quite intelligible how the local professional officers may feel it unpleasant to refer to such different results, yet even they might fairly have been expected so far to let public feelings and duty overcome private feelings, as to consider these facts so essential to a right understanding of the case ; but what can be said of a paper from the general Government of India so entirely yielding to local prejudices as to keep out of sight such decisive proofs that there was no necessity for the failure in the North-West, merely because those proofs came from another Presidency.

Nobody can possibly fail to see that in discussing the failure and the remodelling of the Ganges Canal, this question requires to be answered, how is it that other hydraulic works in India are at this moment extraordinary successes,¹ while this has so remarkably failed ? And what do the officers connected with those works say on the cause of this failure ? In general, when men meet with failure and disappointment, they look about

But further, all the writers of these papers had before them at the time a full discussion of the subject, containing the opinions of such an officer, and these also are entirely ignored, and all the papers are written exactly as if no reason had ever been assigned for the failure, and no plans had ever been proposed by one who from his experience in successful works, had a right to give an opinion on the subject. I am sure in this printed discussion the causes of the failure in the North-West, and the plans for correcting the works, are not only asserted, but fairly argued, and in such a case it seems incompatible with public duty to attempt to decide on a public question of the very first importance, without the least consideration of such facts and arguments.

In these Government Resolutions, it is said, "the high value to the cultivators of works designed for this object is too well known too call for special comment, but to admit of the Government extending them to all parts of the country, as fully as may be desired, it is quite essential that it should be shown that they may as a rule be made remunerative to the State. . . . The Government of India anxiously desires to do what may be practicable in the way of extending the benefits of irrigation to all districts of India. But it will obviously be a necessary preliminary before any extraordinary outlay on such works can be sanctioned or recommended for sanction to Her Majesty's Government, that decisive proofs shall be given that there is reasonable ground for expecting that no financial embarrassment or loss shall arise from such outlay." Who could have imagined that that very Gazette expressing these "anxious desires," should contain such unanswerable "proofs that no financial embarrassment or loss shall arise from such outlay," as official returns of four great works having paid into the treasury five times their cost before two of them are completed, and that no notice whatever is taken of this proof that

ment paper is written exactly as if we had no alternative but to guess whether such is the case or not? The paper then goes on most strenuously to enforce upon the officers of the Department the great duty of "making the works in their charge productive of a fair money return to the State," and for this end they are to do everything excepting one, that is, look into the case of those great works which are now extraordinarily productive, and ascertain why they are so, and from that comparison why the North-West Works have failed.

Who would not have expected that such earnest exhortations to the officers to make their works pay would have ended with something to this purport:—"It is certain from the results of the great hydraulic works of Madras herewith published, that these works can be so constructed as to yield extraordinary returns to Government, and therefore the very first duty of the officers of the irrigation works in the North-West will be to make themselves thoroughly acquainted with the principles on which those works have been constructed, and to discover what the great difference is between them and their own works, which has caused such unnecessary failure, and what can now be done towards putting these works in the same highly prosperous state as those of Madras?"

The comparative returns as given in this Gazette of those five works are for the year 1862-63, as follows?—

	Cost.	Profit.	Loss.	Per cent.
Ganges Canal . .	£2,006,000 . .	— . .	£18,000 . .	£ 1 loss.
<i>Madras Works.</i>				
Godavery	337,000 . .	£160,000 . .	— . .	47 profit.
Kistnah	191,000 . .	29,000 . .	— . .	15 „
Upper Colleroon } Anicut }	24,000 . .	64,000 . .	— . .	270 „
Lower ditto	34,000 . .	52,000 . .	— . .	150 „

In the Gazette the Lower Colleroon Anicut is given in two separate items, because it affects two different districts; in the

above I have added the two together. Now, can it be denied that *the* question is, what is the reason that our work has yielded 270 per cent. net profit, and the Ganges Canal 1 per cent. net loss? and that a work begun ten years after the latter, and not yet near completion, is already yielding 15 per cent? The Resolutions of the Indian Government estimate that the Ganges Canal may yet yield 7 per cent. net profit, after spending £400,000 more on the "remodelling," making the "total capital charge £2,750,000." This, however, leaves out a million, the present amount of interest, making the total sum sunk £3,750,000. This return is also calculated on the present water-rate *doubled*, which was ordered to be carried out at once. When the Godavery and Kistnah Works are completed there is not the least room for doubt that they will return net 100 per cent., and the two Tanjore Works taken together, are now yielding 200 per cent., according to these returns.

I cannot conclude without expressing my own distinct opinion after long examination of this subject, and hearing all that Sir Proby Cautley has said in answer to my arguments, that the locality of the Ganges Canal was at least as favourable as those of the Godavery and the Kistnah, and that there is even now nothing in the world to prevent its being made to yield abundant profits, notwithstanding the great waste of money which has already been incurred, if only the re-formation of it is carried out upon sound principles, such as those which are adopted in Madras, and which produce the astonishing results just published by the Government in the gazette of India.

THE END.

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NOTES

ON THE

REPORT

OF THE

GANGES CANAL • COMMITTEE,

CONVENED BY ORDER OF THE GOVERNMENT OF

INDIA, PUBLIC WORKS DEPARTMENT,

DATED 24 FEBRUARY, 1866.

BY

LIEUT.-COLONEL F. H. RUNDALL, R.E.

CUTTACK:

PRINTED AT THE ORISSA MISSION PRESS.

1866.

PREFACE.

THESE NOTES have been written for two reasons,—one, in consequence of the following paragraph contained in the Committee's Report; the other, on account of the expression which occurs in a Despatch from the Secretary of State to the Government of India, dated London, 24th July, 1866, and published in the Gazette of India of the 22nd September, 1866.

EXTRACT No. 1.

“They regret that, owing to the urgent pressure of his
“duties in Cuttack, Colonel Rundall was unable to join them
“in their inspection of the Ganges; and although that officer
“offered to reply to any written questions referred to him, they
“did not consider it expedient to delay their proceedings for
“that purpose, when personal examination of the localities
“seemed essential for arriving at a correct opinion. So far,
“however, as can be judged from Colonel Rundall's unofficial
“communications, it would appear that his views as to the
“best site for the Weir and Line of Canal near the Solani, do
“not differ materially from those adopted by the Committee.”

EXTRACT No. 2.

“Your not having yourself been summoned to attend the
“Committee is sufficiently explained by your absence from
“India; and the suggestion to the Committee to take the evi-
“dence of Colonel Rundall, joint reporter with yourself on

“the Ganges Canal, evinces the desire of Government that
“the deficiency caused by your absence should be as far as
“possible supplied.”

The concluding words of the Committee's paragraph might lead to the inference that the results of their investigation did not differ materially from my views. My notes will show how far such is the case.

The extract from the Secretary of State's reply to Sir A. Cotton supposes that his views would be represented by my evidence before the Committee. Had I been able even to be present, it would have been at best but a feeble representation of those views. I have, however, given the opinions that twenty-three years' continuous experience on the great Delta Works of Madras and Orissa, and an inspection of the great rivers in the North-West of India and Oude, have enabled me to form.

F. H. R.

CUTTACK,
Sep. 25th, 1866. }

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is not fertilizing.

NOTES ON THE REPORT OF THE GANGES CANAL COMMITTEE.

1.—The first of the advantages ascribed to the higher site at Hurdwar, viz., the diminished quantity of silt entering the Canal, is absolutely a disadvantage. However difficult it may be for the Engineer to deal with, it is nevertheless one of most material importance in the commercial aspect of an Irrigation Project. Every cultivator knows the value of the "muddy water;" and Irrigation from a canal is the more highly esteemed, when it conveys manure in the shape of rich deposit as well as water to the fields. One of the objections urged against the Godavery Project by the Revenue Officers was that the river embankments would deprive the fields of the high manuring from silt which they had hitherto received. The real fact was, that the channels conveyed the silt-laden water all over the district to places which it had never before reached.

2.—The second advantage is more imaginary than actual. It is more difficult to control a river which has a fall of 9 feet per mile than one which has one of only 1' 6"; and where, as in the case of the Ganges at Sookertal, the current is so moderate, the material held in suspension so fine, and the depth of the river so small as 11 ft., the works necessary to prevent its wandering and to train its course need be but of a very simple and cheap description. The fact of the slightest obstacle in the shape of a fallen tree being sufficient to turn it out of its course and set it wandering, only shows that the same obstacle put in the right place, instead of being fortuitously in the wrong, would be sufficient to produce the requisite effect for good, as it is otherwise of evil.

Para 2. Col Randall was

of the immense difficulties of controlling rivers and managing in our life as the lower Ganges. It is not fertilizing.

curable within 50 miles, no other defence is used; the river groynes and revetments—vauganies as they are there called—are built with cocoanut and palmyra trees, faced with mat-work made of the leaves. Perhaps there is no river watched with more care or so successfully as the rivers in Tanjore are, and yet not an ounce of stone is used thereon. There were also successful instances of these post and brushwood groynes on the Godavery; and I have since invariably adopted them on the Mahanuddy, particularly in a situation where the river eroded the bank 300 yards in width in a very few days, and where the soil of the bank is nearly pure sand. Now posts and brushwood cannot be difficult or expensive to procure in the neighborhood of Sookertal, and would doubtless prove as effective there as they have been elsewhere. Moreover, the very construction of the Weir itself would cause such a regulation of the river bed, as to render the control of its banks in its immediate neighborhood comparatively easy.

5.—The extract from Sir Arthur Cotton's letter scarcely gives a fair idea of his views. The whole paragraph, of which it is only a part, impresses the necessity for a *careful watch* upon the changes of the river bed; which unless taken in time would be productive of the most injurious effects—a truth of which there has lately been unpleasant proofs in the case of the Lower Coleroon Anicut, which after having stood successfully for 25 years, and many of those under the care of the President of the Committee has, as I understood from himself, sustained injury just for want of such careful watching.

6.—Sir Arthur Cotton's letter, if it proves anything, proves that after he has seen the Ganges he has reason to alter an opinion formed previously, and that he does not consider the one river less amenable to control than the other.

7.—The extract from Captain Haig's letter has no bearing on the question. He is simply writing of the course of the Upper Godavery in its non-Deltaic region, with a view to explain to those conversant only with the Ganges through its alluvial tract, that the scene of his operations are laid in a portion of the Godavery which does not partake of that character.

Para. 13. 8.—The obviousness, therefore, of the conclusion drawn by the Committee is not so apparent as at first sight it might seem to be.

9.—The body of water being so much smaller, the depth and the velocity of the current so much less, the bed and banks of the Ganges are naturally formed of a material less compact than those of rivers carrying immense volumes at great depths to the sea. Its *power* of erosion, *cæteris paribus*, must be less, and the measures necessary for its control therefore easier and more economical. ⓧ

HEAD WORKS NEAR SOOKERTAL.

10.—It is not clear how the Committee arrive at the quantity of 516,000 c. ft. per second as the discharge of a possible extreme flood at Sookertal, as the *maximum* rise at Futteghur is given at 10' 8," and the application of that rise made to the section at Sookertal gives only 279,000 cub. ft. per second, which corresponds with the quantities estimated by Sir P. Cautley for the discharge at Hurdwar and the Solani, with the additions estimated by the Committee. The actual maximum section given at Sookertal, supposing that the velocity of the spill water followed the same rules as that in the main channel of the river, gives about 450,000 c. ft. per second; but as the Committee do not take this maximum flood into account, it is unnecessary to say more than that it is probably greatly over-estimated, as calculations of spill water generally are.

11.—The calculations which follow of the relative lengths of Weirs on the Godavery and Ganges to discharge their respective floods is given in an apparently popular form; but being so given, do decidedly lead to incorrect inferences being drawn therefrom.

12.—In the first place, the Godavery is treated as though there were an uniform depth and velocity of water over the Weir at the top of the floods, and the latter is given at 8 ft. per second. This is not exactly the case. It is correct for the Dowlaiswaram, but not for that of the Vejaishwaram branch of that Anient, the water-way of which in high floods is

The power of erosion is less, the materials & work upon more unstable. The control therefore is not necessary.

contracted 600 yards out of a total length of 1460 yards, while the bed of the river being two feet lower, the obstruction caused by the Anicut is consequently greatly increased. The velocity over this work at certain stages of the flood is nearer 16 than 8 feet per second. •

13.—The comparison of the velocity over a Weir on the
 Para, 16. Ganges 2200 ft. long is likewise erroneously made. It is stated that it would require to be 32 feet per second, or four times as much as that of the Godavery; but it is omitted to be shown that to obtain that velocity there must be an enormous head of water, and that therefore there must be a correspondingly increased section passing over the lip of the Weir. The actual conditions to discharge 280,000 c. ft. per second over a Weir 2200 ft. long, and submerged four feet on the lower side, would require a head of less than 5 feet. The sectional area of the whole film of water passing over the top of the Weir would thus be increased to 19,800 feet; and the mean velocity would be not 32 feet, but a fraction over 14 ft. per second—less than that which the Vejaishwaram branch of the Godavery Anicut has at one period of the flood to withstand.

14.—Whether it would not be more desirable to lengthen the Weir and reduce the overfall may be a matter for discussion, and I should unquestionably advocate its being so designed; but there would be no more difficulty or risk in exposing the Weir to that overfall than there is at Vejaishwaram,—indeed much less, if a vertical fall is substituted, as thereby the force of the overfall is much sooner destroyed.

15.—Were the Weir reduced one foot in height below what Sir A. Cotton proposed, and increased to 3000 feet in length, the overfall would be reduced to 3 feet. The sectional area would then be 24,000 square feet, requiring a mean velocity of $11\frac{1}{2}$ feet per second to discharge the volume of 280,000 cubic feet. In the event of a maximum flood of 500,000 cubic feet, the sectional area of the film passing over the crest would be increased to 34,500 sq. feet, requiring a mean velocity of about $14\frac{1}{2}$ feet per second—the same result

which the Committee has given for a Weir 4000 feet long and only 5 feet high. The difference arises from the Committee's omission to take account of the sectional area afforded by the head necessary to give the additional velocity.

16.—The afflux in the first instance is $1\frac{1}{2}$ feet, and the other $2\frac{1}{2}$ feet more; but where the level of the maximum flood at Sookertal is so little above the level of the Khadir, an embankment of moderate height would suffice to protect it. At a site where masonry is expensive, and earth-work moderate, the design requiring the least possible of the former should be preferred.

Para. 17.

17.—The expression, "15 feet above the deep bed," used in this para. is calculated to mislead. The fact of the Ganges at Sookertal running a few feet deep, (it is drawn as only three feet,) while at the site selected by the Committee the pool is ten feet deep, shows that the depth is only fortuitous—more in one place than another; and the fact that navigation above Cawnpore in the lowest state of the river is impracticable, shows that there must be less than three feet over the shoals. The height of an Anicut above the *deepest* part of the bed of a river therefore is no criterion of the obstruction it opposes, or of the trial to which it is exposed. Its height over the *mean* bed determines both; for the construction of a Weir across the river tends to equalize the bed both above and below, and in so doing clears away all high sand banks, and depresses the level of the lower bed, yet it at the same time causes all deep hollows to be filled up, and so the bed to become tolerably uniform. The Weir at Sookertal 6 feet above the summer level, would therefore not be 15 feet, but between 8 and 9 feet above the mean bed at that season.

18.—Such being the case, the deductions as to difficulty, danger, and consequent increase of expense thereon, lose their force.

19.—The raising the surface by means of planks on the

Para. 18.

Weir need not be restricted to 2 feet.

On the Godavary the planks are 24 feet, and on the Mahan-

nuddy Weir they will be 3. Because a difficulty has been experienced in the Godavery in their timely removal, is no reason why that difficulty should not be overcome; on the contrary, an improved arrangement is designed for the Weirs in Orissa, which will obviate the difficulty entirely, and allow of all the planks being lowered in an hour.

20.—Passing over the paragraphs 18 to 27, which relate to the Canal, the Committee return to the design of the proposed Weir, which it is said assimilates to a considerable extent to that of the Godavery Anicut.

21.—The sections of both works are given, and it is difficult to see wherein the assimilation consists; for that there are no points of resemblance, except in the width from the Weir to the tail of the apron, is evident, by the pains taken to explain why the difference of dimensions in every particular is adopted. With those conclusions, my experience would have led me to offer evidence of an opposite character.

Para. 29.

First, as regards the foundations.

22.—The upper side of a Weir is exposed to scouring action, principally when pierced with many sluices, which generate parallel currents, or when the alignment of the banks forming the approach thereto has been disturbed. The passage of sand below the work cannot take place unless there is a hole in the rear of it into which it can be forced. It is only when the Weir stands, as it were, on a pinnacle, with a deep hole above and below and close to it, that such action takes place. The instance quoted of the Coleroon Anicut, I have no doubt in my own mind, happened from that cause. The explanation given by Colonel Sim, it must be remembered, was written 30 years ago, when the experience in Weirs across large rivers was but limited; but the explanation afforded by that officer goes to substantiate the above-mentioned view,—because when the width of apron was increased, the filtration decreased, though aided without doubt by the puddling of clay deposited on the upper side, probably by the river itself.

23.—The Committee however believe that, owing to the exceeding fineness of the Ganges sand, this filtration would

be much more likely to occur, and the sand itself be more easily moved. My own opinion is that the opposite action would ensue. The finer the substance of which a filter is composed, the more of the matter held in suspension of the filtered liquid is retained. Consequently more of the Ganges silt would be deposited in the very act of filtration, and so tend to puddle the upper side of the dam sooner than in a river where the sand is coarse and more open. As regards the finer sand yielding sooner to a scouring action than the coarser, it can make but little difference wherever any velocity is generated sufficient to produce a scour at all. When the sand is of unknown depth, as it is in all Delta rivers, no depth of wells will prevent filtration of water taking place, and no wells or blocks could ever possibly be sunk so close together as to prevent an entirely impenetrable barrier or "water-tight screen," unless indeed a single block the whole length of the Weir could be so sunk.

24.—Therefore the water would, notwithstanding, find its way through the spaces between the blocks; and supposing its passage to be greatly obstructed, it would only result in additional pressure being generated, and therefore probably a greater proportional degree of filtration. The experience of Weirs in the Madras Presidency, notwithstanding the accidents alleged, entirely goes to show that great depth of foundations is not essential. The Rallee branch of the Godavery Anicut has no wells; and though there has always been more or less filtration of water beneath it, there has never been any removal of sand, or consequent subsidence of the work.

25.—On the river Mahanuddy, the Weir, which has been built at the bifurcation with the Katjooree, rests on a mass of rough stone, which was originally constructed for the purpose of a groyne, has no wells under its upper retaining wall, which is built with mortar only from one foot below the summer level of the water. The section of the Weir is almost identical with that of the Kistna. Its object being to reduce the quantity of water passing down the arm of the Mahanuddy

contracted. Consequently the plunge or overfall is very violent, and does not as in other Weirs diminish in proportion to the height of the flood, but on the contrary increases. The leakage under this work is almost nothing, although the bed consists of pure sand, and there is a pressure of 11 feet when the upper water is just level with the crest.

26.—As regards the scouring action, of which an example is
 Para. 32. taken from one of the Godavery Reports, the inferences drawn therefrom are not suitable in the particular point to which the Committee apply it. The wing wall in question projected, as stated, 260 yards into the bed beyond the *natural bank* of the river. It was 32 feet high, of which 23 feet were above the level of the then crest of the Weir. This therefore presented an enormous obstacle to the river in full flood. Let this be contrasted with the position of the Weir at Sookertal, where it is proposed not to contract the ordinary water-way of the river between its *natural banks*, but to double it by making the Weir 4000 feet in length. In a maximum flood, supposing that the Khadir were not embanked, the wing wall would stand about six feet above the level of the ground, which the ordinary flood does not reach, and a maximum flood overtops about $2\frac{1}{2}$ feet.

27.—The Committee state that the length of Anicut limited
 Para. 33. to 4000 feet is only $\frac{9}{16}$ of the width of the channel of the river during high flood, and add, that it is therefore certain a scouring action similar to that above-mentioned would result. It would seem that they could not have been aware that the length of the Godavery Anicut, when compared with the width of the *surface of the river when in flood*, is precisely the same, viz., 4000 out of 7000 yards!

28.—The islands on which the respective branches of the Anicut abut being covered from 3 feet to 6 feet deep in a maximum flood, it was of course necessary to throw high embankments across them in order to prevent the flanks of the Anicut from being turned, but no injurious effects have been thereby experienced, and no action similar to that produced, as on the wing wall just mentioned.

29.—The experience gained there then does not certainly corroborate the necessity for the expensive precautions which have been recommended for the Sookertal Weir.

30.—The length of the wing walls, and the masses of concrete allowed by way of protection, are certainly four times greater than there is any occasion for; while for the protection of the natural banks of the Khadir, brushwood spurs would, I am persuaded, be found more effectual than any stone work.

31.—The closing of the dam would undoubtedly be attended with difficulty and expense; but one source of difficulty experienced at the Godavery would be wanting in the Ganges, and that is the *height* of the temporary dams. *There* it was necessary to retain the water on a high level to ensure sufficient depth for navigation for the transport of material. The floor of the under sluices being 4 feet above the level of the bed, no water could pass through them until the river had been raised to that level, and a further head was necessary in order to obtain the requisite sectional area and velocity. In November, when operations in the bed of the river first commenced, the volume passing was 18,000 to 20,000 cubic feet per second; and in November last, when the temporary dam across the Mahanuddy was commenced, the volume was 30,000 cubic feet per second. In the Ganges, the floor of the sluices are proposed to be laid on a level with the bed of the river; hence the height of the temporary dam, and therefore of the head of water would necessarily be much less.

32.—The dimensions for a Weir across the Ganges at Sookertal, where the section as given is preferable to that at Raoli Ghat, I consider as altogether unnecessarily large, and not warranted by the experience gained on the Madras Works.

33.—The section given of the Godavery Anicut is, if I mistake not, that of the Vejaishwaram branch, the height of which is now 16 feet, exclusive of the boards above the summer level. The length of apron shown is 153 feet from the crest of the Weir.

34.—The section proposed for the Sookertal Weir is a wall 5 feet above low water, or 8 feet above the mean bed in sum-

mer. The length of apron, with vertical fall, is given at 170 ft., of which no less than 50 feet are to be of dressed stone.

35.—The section of the ~~Mahanuddy~~ Anicut, in its finished portion this year, is a wall 10 feet above the lowest summer surface, with a sloping apron of 100 feet from the crest of the Weir. For the greater portion of it, where exposed to any considerable overfall, the apron is only 75 feet wide.

36.—In Weirs with a vertical fall, it is absolutely a mistake to make the cut stone apron too long. It should be no longer than is necessary to withstand the blow of the overfall, and the counter blow of the recoiling surf which takes place at particular stages of the flood. The object being to kill the accelerated velocity as soon as possible, the water should meet the inequalities of the rough stone apron at a short distance from the overfall. In a long-dressed apron, the water shoots off without meeting any obstacle, and consequently maintains its acquired momentum for a longer period.

37.—The design for the Sookertal Weir that I should have recommended as providing for every contingency, and *erring on the safe side*, would be,—height of wall 6 feet above low water, with 3 feet of planking; an apron of 100 feet, of which 30 feet should be cut stone and 70 feet concrete blocks, with an intermediate retaining wall 30 feet from the cut stone apron; one row of wells under each wall, not exceeding 8 ft. in depth. The Weir to be 3000 feet long.

38.—Adopting the Committee's rates, which not only include 50 per cent. to meet extra expense in construction, but 10 per cent. again on such increased total, the estimate for the Weir would amount to 17,80,000 instead of 44 lacs.

39.—This estimate is nearly double that of the Godavery Anicut, which is four times as long, and twice as high. The cost of the latter amounted to Rs. 75 per running foot; that for the former allows Rs. 583, or nearly eight times as much. The cost of masonry at the Godavery was Rs. 2-8-0 per cub. yard, and of rough stone 1-0-0, equal to 9-4-0° and 3-11-0 per 100 cubic feet, being one-third and one-sixth of the respective rates at Sookertal.

40.—Adopting the Committee's estimate for the Canal, though I should not have considered it necessary to provide all the precautions which they have done, the total expense of the Project would be,—

For the Weir -	-	-	-	17,80,000
Canal -	-	-	-	68,75,000
				<hr/> 86,55,000

This estimate provides for the passage of 5000 cubic feet per second. In para. 19, the Committee state that the discharge at Sookertal was found in April last to be 5300 cubic feet per second, while a supply of upwards of 5000 cub. feet was entering the Canal at Hurdwar; but as the river was then slightly higher, they estimate 5000 cub. feet as the most that would be available.

41.—In para. 58 they again state, that when the river was at its lowest, the volume at Rajghat was 5630 cubic feet per second. It is presumed that, as these two measurements were taken during the same month, the quantity entering at Hurdwar was also the same. This would lead to the conclusion, then, that if the Canal could take off the full quantity for which it was originally designed, or 7000 cubic feet, 3000 cub. feet would be available at Sookertal, and about 3500 cub. feet per second at Rajghat.

42.—In para. 91 the Committee say, that nearly two-thirds of the full supply, equal to 4666 cubic feet, has been passing down the Canal for the last twenty months without interruption—showing a deficiency of 2333. It may be presumed, therefore, that the Sookertal Canal, if executed for 5000 cub. feet, would carry an excess quantity of 2667 cubic feet, which would be available for the cultivation of a corresponding number of acres. In para. 65, the Committee hope that the quantity of land irrigated may amount to 200 acres per cub. foot of discharge. The excess in the Sookertal project, therefore, would be sufficient to irrigate 5,33,400 acres.

43.—The cost of distributaries is stated to be at 5 Rs. per acre: therefore 26 66 000 would have to be added, and bring

up the total cost to $86,55,000 + 26,66,000 = 113,21,000$: the gross value of the water would, at 2-8 per acre, amount to 13,33,000, or 12 per cent. on the expenditure; but it is stated that the net profits are only 1-8 out of 2-8, or three-fifths of the value of the water sold; they would therefore amount, on the gross cost of the project, to $\frac{3}{5} \times 12 = 7\frac{1}{5}$ per cent.

44.—In para. 153, however, the Committee consider that the maintenance charges may probably not exceed 7 lacs per annum on a total expenditure of 325 lacs, or about two and one-eighth per cent. So that the Sookertal project therefore would yield 10 per cent., exclusive of receipts from navigation. As Major Crofton's project, however, is estimated at 45 lacs, it would, in order to institute a really true comparison, be requisite to deduct that sum as due for the remodelling of the Canal, which would leave $112,91,000 - 45,00,000 = 67,91,000$ against the Sookertal project, or which the sum of 13,33,000 to be realizable by sale of extra supply would be $19\frac{1}{2}$, yielding a net profit of three-fifths, or 12 per cent., or eventually of 17 per cent!

45.—But again the Committee observe, in para. 49, that there is not likely to be much above 3000 c. feet available at "Sookertal when 7000 c. ft. are entering the Canal at Hurdwar. "In that event the great cost of a Weir across the Ganges, "which must be the same whatever quantity might be taken "from the river at Sookertal, would seem to render the consideration of a separate project from that site superfluous."

46.—It is to be regretted that the investigations, or rather calculations, were not carried a little further. Taking the Committee's own estimate for both Weir and Canal, and diminishing the latter only by the proportionate amount of sectional area in the "cuttings" to carry the reduced quantity, leaving the Weir, the embanked portion of the channel and the drainage works as they stand in the estimate, the following is the result:—

Total estimate for Canal	-	-	-	-	-	47,95,458
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this expense may be found reducible to 3 Rs. If so, the gross estimate would be reduced by 12 lacs, or to 86,00,000, and the returns be raised to nearly $17\frac{1}{3}$ per cent., on which the eventual net profits would amount to 14 per cent.

48.—The proportion of three-fifths for net profit implies that the current expenses amount to 40 per cent. of the gross receipts. The proportion in the Madras Delta Works, where the first outlay has been so small, is not more than from 5 to 6 per cent., inclusive of establishments; and as the expectation expressed by the Committee that the maintenance charges may eventually be 7 lacs, or at the rate of 8 annas per acre, 2 and one-eighth per cent. on the outlay, the proportion of three-fifths needlessly under-rates the eventual net profits.

RAJGHAT PROJECT.

49.—In para. 54 the Committee, while enumerating essential differences between the Godavery and Ganges, have omitted to notice one of the most important actions to which the Weirs in the Madras Deltas are exposed, in a much greater degree than can happen in the case of those across the Ganges. It is neither on the duration nor the velocity with which the water flows over a Weir, that comparisons can be drawn as to the difficulty in securing the permanency of a structure in different rivers. The power exerted depends, not on the velocity only, but on the volume or *weight* of water multiplied into that velocity,—in other words, the *momentum* with which the mass moves. In the Kistna, the column of water over the Weir in an extreme flood is 17 feet, and moves with a velocity of 12 feet per second, or 8 miles per hour—the momentum of which may be represented by $17 \times 62\frac{1}{2} \times 12 = 12,750$. In the Vejaishwaram branch of the Godavery the column of water is 16 feet, also moving with an equal velocity of 12 feet per second $= 16 \times 62\frac{1}{2} \times 12 = 12,000$. In the Ganges, the column of water over the Weir proposed by the Committee would in the *maximum* flood be $10\frac{1}{2}$ feet, moving with a velocity of $8\frac{1}{2}$ feet $= 10\frac{1}{2} \times 62\frac{1}{2} \times 8\frac{1}{2} = 5578$; and in the design I should recommend, $11 \times 62\frac{1}{2} \times 14\frac{1}{2} = 9968$.

This I think is not sound.

50.—It is at this time when the Copping or top stones of the Weir run greatest risk of being torn off their bed; but it is when the lower water is level with the crest, that the greatest injury is likely to occur on the *Apron* and on the bed beyond, owing to the difference of level between the two waters, and consequently the plunge being then greatest. In a vertical overfall, the effect of the plunge is deadened almost immediately. The accelerated velocity with which the water shoots off will, if the channel be regular, be quite lost within 100 feet; and therefore, as before explained, the protective apron of vertical falls need not be nearly so long as those of sloping Weirs like the Kistna or Godavery.

51.—From what has been said, it follows that the relative forces which the three Weirs have to provide against are as 13: 12 & 5·6 or ~~12~~ according to whichever design may be adopted for the Ganges. The dimensions given by me are such as past experience has shown to be abundantly sufficient. How much then in excess are those of the Committee's design, which has to resist only half the momentum!

52.—For these and similar reasons to those expressed regarding the Sookertal Weir, I consider the section given to the Weir at Rajghat equally unnecessary, and its cost therefore proportionately over-estimated. However, without recapitulating these particulars, and accepting the Committee's estimate both of Weir and Canal, it seems to have escaped their notice, that while in para. 66 they state only two-thirds of 5000 cub. feet per second could be relied on if the Ganges Canal took its full supply, they have calculated the *reduced* profit of 5 per cent. on the *whole* outlay necessary for the conveyance of 5000 cub. feet.

53.—If the smaller volume is to be the guage of the profits, it should be also of the size and cost of the Canal which has to convey it. The earth-work is estimated

at 50,84,000, two-thirds of which is -	-	33,90,000
Add for bridges of less length, at 20,000	-	2,00,000
Crossing nullahs, &c.	- - -	4,50,000
		<hr/>
		40,40,000

Brought forward-	-	-	-	40,40,000
Contingencies, at 8 per cent	-	-	-	3,23,000
				<hr/> 43,63,200
Superintendence, at 7 per cent	-	-	-	3,05,424
				<hr/> 46,68,624
Add for Weir-	-	-	-	45,50,280
				<hr/> 92,18,904
Distribution to 6,66,600 acres, at 5 per cent.				33,33,000
				<hr/> 125,51,900

Gross return from 6,66,600 at $2-8=16,66,500$, or $13\frac{3}{4}$ per cent., of which the eventual net profits would be 11 per cent., and not 5 per cent. only, as stated in the para. referred to.

54.—With the Weir reduced to reasonable dimensions, the expense would, even at the Committee's Rates, not exceed ~~18,00,000~~, and thus reduce the gross cost of the Project by 27,00,000, making it 98,00,000, on which the return would be 17 per cent., and the net profit $13\frac{1}{2}$ per cent., capable of being increased by economising the cost of distribution, as previously explained.

HEAD WORKS ON THE JUMNA.

55.—Had any evidence been asked from me on this Project, my opinions would have coincided entirely with those of Mr. Sibley, especially as expressed in Paras. 3, 4, and 5.

56.—That gentleman's remarks on the difference of design proposed for the Weir on the Jumna are perfectly correct. The fact of there being an unlimited supply of suitable stone should govern the particulars of design. I have already shown that Wells form by no means a necessary condition in the construction of Weirs; and in the instance of the Jumna might be entirely dispensed with, or, if used at all, need be but shallow.

57.—The use of shallow wells would obviate the necessity of waiting for one season before building the retaining walls, and it is for this reason more than any other they are used in localities where there is an abundance of stone available. I

would however recommend the adoption of a different section for the work, one similar to that lately built over the branch of the Mahanuddy called the Beropa, where the conditions are almost identical. The stone with which that Weir has been built consists of laterite blocks, taken out of an old Fort-wall. The foundations of the front wall rest on a single row of wells of brick in clay, filled with laterite rubble, 6 feet in diameter and 6 feet deep. A second wall 30 feet from the front wall, also built on similar wells, retains the first apron, the upper course of which consists of laterite blocks 2 feet square, and 12 to 15 inches thick, packed firmly together so as to present a serrated edge: the lower apron consists of the same stone, and is finished off with a course of smaller size. The width of the whole, from the crest to the tail, is only 75 feet. The height of the front wall above the summer level and bed is $7\frac{1}{2}$ feet. The depth of water which passed over it in the recent floods was 7 feet. The difference of level when the tail water was even with the crest was 3 feet, and the afflux about 6 inches at the top of the flood. The length of Weir is 2000 feet from bank to bank. When the water fell the other day to within $1\frac{1}{2}$ feet of the crest, not a single stone appeared to have been displaced. The distance from which stone had to be conveyed is two miles—about the same apparently as that at the Jumna. The total cost, inclusive of two sets of head sluices to discharge 2000 cub. feet per second, with a head of 4 inches; two locks 150 feet long by 20 and 17 feet; and two sets of under sluices of 20 vents each, have up to this time cost only Rs. 1,70,000, and occupied exactly 12 months in construction. Mr. Sibley's estimates therefore for a Weir only 500 feet longer are superabundant. I would however recommend the Weir being raised 2 feet, with 2 feet of boarding, which would reduce the depth of cutting in the Canal by 4 feet, and make a material saving on that part of the project; so that instead of the whole project costing 39 lacs, it would probably not exceed 30 lacs, instead of 51 lacs as estimated by the Committee. (Vide para. 81.)

50. A head of 2200 feet per second would provide irri-

gation for 660,000 acres, the cost of distribution to which, at Rs. 5 per acre, would be 33 lacs. Adding this to the cost of the Main Works, will give a total of 63 lacs, on which at 2-8 the return would be 16,50,000, or 26 per cent.; and if subject to a diminution of say even 6 per cent. for maintenance, would yield an eventual profit of 20 per cent., exclusive of receipts from navigation.

59.—As a Project for supplementing the deficiencies of the Ganges Canal, the whole question turns of course on the quantity of water likely to be available. If this be sufficient, then, as a comparison with a Project for the supply to be drawn from the Ganges, it is decidedly preferable, on account of its economy and capability of quick execution; while its advantage in affording an additional line of navigation, far superior to that of the river at all seasons of the year, right up to Delhi, would seem to point to its adoption in any case as the most preferable project of any suggested, independent of that most important of all reasons which ought only to be resorted to—*failing every other*—viz., closure of the Canal, whereby the cultivators of such a large area of land as is now irrigated must be thrown out in their agricultural arrangements, which have been made hitherto in dependence on the water. The mischief that will ensue cannot be calculated. It will take some ~~years~~ before they will again feel assured that in another two years they may not again be called upon to forego the use of the water; and this argument receives additional strength from the statement of the Committee, that for the last twenty months an abundant supply has been continuously furnished. Previous to that time the closures had been frequent; and now that confidence has begun to be established, as evidenced by the area irrigated steadily increasing, it will be fraught with much more mischief than has been contemplated to adopt measures by which that confidence will be destroyed. The essence of all Irrigation Projects is certainty and continuity of supply.

60.—This point does not appear to have entered into the Committee's discussions, at least it is not touched upon in their

Report. At the risk then of appearing obtrusive, yet as an advocate of Irrigation Projects, I cannot help pointing out, that the main argument for more than one head of supply for so extensive a tract of country, rests on the paramount necessity of adopting every possible precaution that the whole irrigated area shall not be dependant on the stability of each and every work in a single Main Line. At present, if a serious accident should happen to any one work above Roorkee, the whole tract is deprived of water. If this prove so serious an evil with 500,000 acres irrigated, it will be immensely aggravated when the full quantity due for 7000 cubic feet per second, or 1,400,000 acres are receiving irrigation. The loss of one year's revenue would be equal to the cost of two Weirs on the Ganges, or six such Weirs as designed by Mr. Sibley across the Jumna; whereas, with two or more heads of supply, a proportional amount of the area only would be affected; and it is especially on the ground that the Remodelling Project, as it has been termed, cannot provide against this contingency, that it is not desirable. As the great mass of country to be irrigated lies below the 115th mile, to make its well-being dependent on the stability of every masonry work between the head and that point, when it *can* be otherwise provided for, is to incur an unjustifiable risk, if the Project be looked upon as a commercial undertaking, and much more so ~~as~~ considered a philanthropic one, for the sole purpose of "ameliorating a famine."

61.—As on these grounds my testimony would have been opposed to the Remodelling Project, I forbear from making any remarks on the chapter devoted to that subject; but I strenuously advocate the continuation of the Canal to Allahabad, inasmuch as the navigation of both rivers up from that city is attended with difficulties in the low water season, while during the freshes the river route is both tedious and expensive.

62.—On the financial state of the Ganges Canal, no question would I presume have been put to me; but the following paragraphs, which contain a comparison with the results of

Madras Irrigation Works, would probably have necessitated some queries.

63.—With reference to the statement made in para. 169 I answer, that in the Godavery District three Channel Heads, such as would answer to Inundation Canals in Northern India, existed prior to the commencement of the Anicut Project.

64.—Of these, one in the Eastern and one in the Western Delta were able to be taken advantage of. The third had its head 20 miles lower down, and was useless. In the Central Delta there was no such channel. The two used were of small section, so that the saving in excavation was very small. They *were* useful, however, in allowing even a small body of water to be conveyed immediately the river was raised by the Weir. In the Kistna, the channel heads were larger; and in Tanjore there had been a system of irrigation of long standing, which however, from neglect, had been so deteriorated, that it required a large outlay for its restoration.

65.—To the Committee's conclusion in para. 173 I should have demurred. The question is not whether Irrigation Works in Northern India ought not to be *as* remunerative as those in the South, but whether the principles on which they have been projected have not been such as prevented them from being ~~as~~ remunerative as they *might* and *should* have been.

66.—And here my remarks ought probably to close; but as a Madras Engineer, whose whole career has been passed amongst the great Hydraulic Works of that Presidency, and accustomed to consider their bearing in every point of view, professional, commercial, and philanthropic, I trust I may be excused for passing a few comments on the Appendices to the Report made by the Madras Members of the Committee.

67.—The President states, that he has long considered the financial results of Madras Works to have been over-estimated, for the reasons he advances. These results, however, were not statements prepared by Engineer Officers, or by irrigation partisans, but by the civil servants of Government, who were

68.—The Professional Papers of the Madras Engineers contain an article written by Colonel Lawford himself twenty years ago, in which he shows that the bare returns from extended irrigation even then amounted to $35\frac{1}{2}$ per cent., without allowing for any effect produced on the general revenue of the district by means of improved communications, &c.

69.—Ten years later, when a most elaborate investigation ordered by Government was made into this very question, the Board of Revenue showed that taking only the increased extent of land brought under cultivation, and the increased revenue derived from the substitution of irrigated crops for dry grains, in other words, “Water Rate,” “that for a capital outlay of Rs 2,17,359 the Government have received a clear gain of Rs 41,20,528 in 16 years, or a profit of 118 per cent. per annum.”

70.—The Secretary to the Board in the D. P. W. wrote at the same time, “It must not be forgotten that the ~~Delta~~ had been for an unknown period of time the field of a most extensive system of Irrigation, rendering it by far the richest territory, area for area, in Southern India; but its prosperity was placed in jeopardy by the difficulty of utilizing the entire supply of water brought down by the river, and that difficulty was simply, effectually, and at trifling cost, removed by the Anicuts. The source of all the wealth of the Delta is the river; the Anicuts are only conditions essential to the transmission of the water to the land; and as other conditions not less essential and of far greater magnitude were in active operation before the Anicuts, it must never be supposed that when such conditions are wanting works similar to the Anicuts would produce any thing approaching to similar results for a length of time. In the Godavery Delta, for example, besides the Anicuts, the *entire system of Irrigation had to be created*, and the profits on the capital expenditure will necessarily be at first diminished in proportion to the extent of subsidiary works required for their realization. But these profits will evidently by degrees far surpass in actual amount those realized in Tanjore, on

“account of the far greater field for improvement afforded by
“the Godavery Delta.”

71.—The above extracts show that the Revenue Statements were neither prepared without reason, nor in ignorance of the peculiar circumstances which prevailed in Tanjore. Let the cost of all the subsidiary works previously existing be added to that of those which produced the increased prosperity, and it will be found that the results will not be far different from that arrived at by the Board of Revenue; for it must at the same time be borne in mind, that had it not been for these existing works, the Province could not have attained the pitch of prosperity which it had reached, but would have been in the same distressed condition as the Godavery Delta, where “the entire system of irrigation had to be created.” The difference of revenue between dry and irrigated lands, or, in other words, “Water Rate,” would have had to be credited for the *whole* area commanded by those subsidiary works, one year’s revenue from which would have proved sufficient to furnish Tanjore with its whole net-work of channels. It does not appear, then, that in the district with which Colonel Lawford himself was most familiar, the results of the Irrigation Works had been over-estimated.

72.—Again, in para. 140 of their Report, the Committee “entirely agree with Colonel Dyas’ views,” that “*all* proceeds resulting from the construction of a work of Irrigation should be clearly shown.” It is on this principle that the results of Madras Works *have* been shown, as the great Delta Systems affect the revenue in every particular; and that they *have* done so is undeniable and apparent from the fact that in the “less favored” adjoining districts, *also* “on the sea-board,” the revenues have *not* similarly advanced. That Irrigation is less needed in Northern India is scarcely borne out by the numerous wells that meet the eye in every direction, and by the still more significant fact that our predecessors in the government of this country have every where left traces of the importance they attached to the value of water, by the construction of works on scarcely a less magnificent scale than those recently

undertaken by the British Government, and by the yet more tangible evidence of the steadily increasing area of Irrigation under all the Canals as yet executed.

73.—Colonel Anderson's Memorandum would lead to the supposition that the returns from the Madras Delta Works, owing to certain advantages possessed in leading the water to the surface of the country, must necessarily be greatly in excess of any other, and that few other works could be undertaken elsewhere at the same proportional expense. In Southern India, Irrigation Works under every conceivable variety of circumstances have been carried out, and I doubt not it will be found with equal, if not greater remunerative results.

74.—In the Central Districts of Bellary, Arcot, Coimbatore, there are Canals and Projects of a totally different character from the Delta Works, and which have proved equally productive, with the cost of every item included.

75.—The Memorandum would also lead to the belief, that the greater portion of the Returns in the Madras Deltas arose from the great extent of waste land brought under cultivation. To this I demur. In the first place, waste lands in the Madras Presidency do not mean only lands never hitherto brought under cultivation, but also those allowed to lie fallow, either from paucity of population or precariousness and poverty of crops cultivable thereon. The per-centage of such lands brought under the plough again, in the Godavery District at least, is small compared with the extent of *existing cultivation improved* by the water. The greater proportion of revenue derived has been "Water Rate," levied for the *bona fide* use of water, for the conversion of dry into irrigated lands, and for the substitution of transplanted for broadcast rice, adopted so extensively because of the largely increased out-turn of produce obtained thereby,—a result not peculiar to one part of India more than another, as applicable to the North-West as to the South, and therefore not conferring any more particular advantages to the Deltas of Madras than to the Doabs of Upper India. The fact of the Canals in Northern India for the Irrigation of the Doabs requiring to be carried much longer distances before the

surface of the country can be reached is well known, and has never been ignored; but it yet remains to be shown that they could not have been constructed at less expense, and the water led to the country over an equal tract in a less period of time.

76.—I have adopted the Committee's Rates for materials in calculating the cost of the Anicut across the Ganges; but I must observe that in Major Crofton's Report (para. 93) he speaks of "kunkur blocks of compact texture which will stand pressure" being found at the 110th mile, and of the ~~same~~ material being obtainable at Nirgajnee, at the 42nd mile, of a less hard description, but appearing "to stand the erosive action of water well, and answering admirably for rubble work."

77.—In his estimate for works at the 110th mile, he reckons the cost of kunkur masonry at Rs. 17 per 100 cub. feet. The cost of such masonry in the Sookertal Anicut would be Rs. 17 plus the cost of water carriage for 70 miles, and land carriage from 8 to 10 miles. Taking the former at (0.5 rupee) per 100 cubic feet, and the latter at (0.75 rupee), the cost of kunkur masonry at Sookertal would be 60 rupees per 100 cubic feet, or about 9 annas per cubic foot; whereas the cost of cut stone is put down at 2 rupees 8 annas per cubic foot. If Major Crofton's description of the kunkur stone is correct, that the softer description even "stands the erosive action of water well," then the harder material found at Boolundshuhur would certainly answer equally well as Bhurtpore stone, especially in Weirs exposed to such a very small trial as those designed by the Committee. This item alone would reduce their estimate for the Sookertal Weir $6\frac{1}{2}$ lacs of rupees.

CONCLUSIONS.

The conclusions fairly deducible, therefore, from the late investigations, coupled with the observations above made, are,

I. That the Sookertal Project is feasible, and would, if carried out according to the Committee's design, only modified for the actual volume of water available, yield an eventual return of 10 per cent.

II. That if the Weir be divested of superfluities, and built as actual experience would justify, the return would be $12\frac{1}{2}$ per ct.

III. That if credit be taken for the sum estimated for the Remodelling Scheme, and the balance only charged against the Sookertal Project for the diminished volume carried, the return would be 17 per cent.

IV. That the Rajghat Project, is also feasible,² and on the Committee's design would yield 11 per cent., but with a modified Weir yield $13\frac{1}{2}$ per cent.

V. That Mr. Sibley's Project of a Weir across the Jumna ~~Canal~~ is, in the event of a sufficient supply of water being available, a more economical and profitable mode of supplementing the deficiency of the Ganges Canal, and therefore preferable to the other two Projects, as capable of more speedy execution, and affording a promise of a profit of 20 per cent.

VI. That as it would avoid the loss of revenue, and, what is of still greater consequence, the loss of confidence by the cultivators, it is the proper work to carry out in preference to the "Remodelling scheme," which only ought to be resorted to failing every other method.

VII. That for the same reasons, if sufficient water is not procurable from the Jumna, the Project at either Sookertal or Rajghat should be carried out.

VIII. That under any circumstances, two of the proposed Works should be prosecuted, inasmuch as besides being more remunerative than the present line, which it is only hoped may eventually yield 8 per cent., they will afford irrigation to another million of acres; but above all, by giving additional heads of supply, they will relieve the great mass of the irrigated country from the risk of being dependent for its supply on one long line of Canal furnished "with Masonry structures of a difficult nature," (vide para. 122,) which, especially near the head, are exposed to the irruption of several mountain torrents, an extraordinary flood down any one of which may inflict irremediable injury, necessitating the stoppage of Irrigation over the whole tract.

F. H. RUNDALL, LT. COL.,
ROYAL ENGINEERS, MADRAS.

Estimate for Weir across the Ganges near Sookertal.

I.

Cut stone	$30 \times 1\frac{1}{2} = 45$		
„	$5 \times 2 = 10$	55 at $2\frac{1}{2}$	137.50
Concrete or Brickwork,—			
Floor	$39 \times 4\frac{1}{2} = 176$		
Body Wall ..	$5 \times 6 = 30$		
Rear Apron ..	$70 \times 4 = 280$		
Front Apron	$15 \times 8 = 120$		
Lower Wall..	$4 \times 5 = 20$	626 at 30	187.80
Wells	$3 \times 6 \times 8 =$	144 at 30	43.25
			<u>368.55</u>

For Weir, 368.55×3000 .. 11,05,650

Posts and Planking 15,000

Total 11,20,650

II.—*Wing Walls.*Walls $25 \times \frac{3 \times 10}{2} = 162.50$ at 30 48.75Wells $2 \times 6 \times 8 = 96$ „ „ 30Concrete Apron $15 \times 8 = 120$ at 20 20

Total per foot running 98.75

Ditto for Wing Walls 98.75×400 39,000Concrete Blocks and Protective Groynes of Posts
and Brushwood, say 50,000*Abstract.*

Weir 11,20,650

Wing Walls 39,500

Protective Groynes 50,000

Head and Under Sluices 2,50,000

Embankments, 50,000

15,10,150

Contingencies at 10 per cent. .. 1,50,000

16,60,150

Establishment, at 7 per cent. .. 1,16,210

17,76,360 .

214 (9)
RESULTS OF IRRIGATION WORKS

IN

GODAVERY DISTRICT,

AND

REFLECTIONS UPON THEM.

PARTS I AND II.

BY

OR-GENERAL SIR ARTHUR COTTON,

SECOND EDITION.

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Results of Irrigation and Navigation Works in Rajahmundry (now Godavery) in the Madras Presidency.

Average of Eleven Years' Collections (1836-46) in Rajahmundry	...	£190,000
Ditto of part of Masulipatam, annexed in 1861, about	...	30,000
Total for Godavery District	...	<u>£220,000</u>

Collections in Godavery District (exclusive of above-mentioned part of Masulipatam), Cost of Works, &c., from commencement of Irrigation Works.

Year.	Estimated for Repairs, &c.	Remaining Cost of New Works.	Total Expenditure each year.	Total Cost of Works up to end of preceding year.	Collections.	Increase of Revenue each year above former average.	Net Increase deducting Repairs.	Per-centage of Net Profit each Year upon Capital.	Aggregate Net addition of Revenue.	Deduct Total Cost to same time.	Clear additional Receipts deducting all expenses.
	£	£	£	£	£	£	£	Per cent.	£	£	£
1846-7	4,000	20,000	24,000	.....	220,000	30,000	26,000	.....	26,000	20,000	6,000
1848	4,000	30,000	34,000	20,000	230,000	40,000	36,000	180	62,000	50,000	12,000
1849	4,000	18,000	22,000	50,000	230,000	40,000	36,000	72	98,000	68,000	30,000
1850	4,000	22,000	26,000	68,000	220,000	30,000	26,000	38	124,000	90,000	34,000
1851	4,000	15,000	19,000	90,000	250,000	60,000	56,000	62	180,000	105,000	75,000
1852	4,000	38,000	42,000	105,000	250,000	60,000	56,000	53	236,000	143,000	93,000
1853	6,000	44,000	50,000	143,000	250,000	60,000	54,000	35	290,000	187,000	103,000
1854	7,000	63,000	70,000	187,000	240,000	50,000	43,000	23	333,000	250,000	83,000
1855	10,000	62,000	72,000	250,000	250,000	60,000	50,000	20	383,000	312,000	71,000
1856	16,000	79,000	95,000	312,000	260,000	70,000	54,000	17	437,000	391,000	46,000
1857	19,000	32,000	51,000	391,000	260,000	70,000	51,000	13	488,000	423,000	65,000
1858	20,000	8,000	28,000	423,000	270,000	80,000	60,000	14	548,000	431,000	117,000
1859	20,000	13,000	33,000	431,000	300,000	110,000	90,000	21	638,000	444,000	194,000
1860	20,000	7,000	27,000	444,000	320,000	130,000	110,000	25	748,000	451,000	297,000
1861	21,000	5,000	26,000	451,000	390,000	200,000	179,000	40	927,000	456,000	471,000
1862	22,000	5,000	27,000	456,000	350,000	160,000	138,000	30	1,065,000	461,000	604,000
1863	22,000	8,000	30,000	461,000	380,000	190,000	168,000	37	1,233,000	469,000	764,000
1864	22,000	8,000?	30,000?	469,000?	390,000	200,000	178,000	37	1,411,000	477,000	934,000
1865	22,000	8,000?	30,000?	477,000?	400,000	210,000	188,000	39	1,600,000	485,000	1,114,000
Totals ...	251,000	495,000	746,000	.....	5,470,000	1,860,000	1,609,000	Av. 42			

I should mention that the statement I have shows only the total sum expended, and does not divide it into Capital and Repairs. I have therefore estimated the latter at *four per cent.* on the Capital as it was expended, excepting for the first four years, when I have allowed £4000 a year, because there were old works which were kept in repair out of this money. As the whole of the money expended is thus accounted for, there cannot be any material error in this mode of dividing all between Capital and Repairs.

RESULTS OF IRRIGATION WORKS, &c.

PART I.

IN the Administration Report, the Revenues of the last five years are given at £30,000 more than is here stated, on account of the portion of Masulipatam annexed at that time. I have deducted this £30,000, which was, I believe, about the revenue of that tract before the Works.

Former average Revenue, including portion of Masulipatam, afterwards annexed	£220,000
Revenue of 1864-5	430,000
	<hr/>
Increase	£210,000

Or 95 per cent. on former Revenue.

To show how far this is the effect of the Works, we may compare the progress of this district with that of the adjoining districts, excepting Kistna, which is undergoing the same treatment:

Average Revenue of Vizagapatam, Nellore, Cuddapah, Bellary, and Kurnool for five years preceding 1846	£1,059,000
Revenue for 1863-4	1,238,000
	<hr/>
Increase	£179,000

Or 17 per cent.

But of this a large portion also is due to improved irrigation, and to the large expenditure on the Toombuddra Works in Kurnool, £700,000, which must have materially affected the Revenue of that District, so that the increase from other causes probably is not more than 10 per cent., and we may fairly conclude that nine-tenths of the increase in Godavery is due to the new Works.

The returns at present upon *Capital Expended* are as follows :

Increase of Revenue	...	£210,000
Capital expended	...	477,000
		<hr/>
Gross Returns per cent.		44
Suppose Repairs, &c.	...	4
		<hr/>
Net Returns	...	40
And deducting due to		
other causes	...	4
		<hr/>

Net profit due to the Works 36 per cent on capital.

In the column showing the net increase at the end of each year, it will be seen that, without any exception, there was always a clear gain in the Treasury above all that had been expended in capital and repairs, the lowest balance having been £46,000, excepting in the first four years. And the *average profit*, from the very first, has been 42 per cent., or, deducting 4 for repairs, &c., 38 per cent. for net profit.

But it will thus be seen that when we say that the profit is now 36 per cent. on the capital, that it is on a

the Treasury every year, and much more. To show the total gain:—

The Revenue for the nineteen years would have been at the former rate		$\text{£}190,000 \times 19$	$\text{£}3,610,000$
The actual collections have been		...	5,470,000
Increase		...	1,860,000
And deducting cost of Works, Repairs, &c.			746,000
Clear additional receipts			1,114,000

In this amount, I believe, the cost of the European establishment is not included, in which case, perhaps, £100,000 must be deducted. It thus appears that there is already about £1,000,000 in the Treasury clear above what there would have been if the Works had not been executed; and in the face of this result it is continually said that the Government cannot find money for such Works.

Taking *the Capital* at £485,000, the Works have already been paid for more than three times over; the profit, after deducting repairs, being £1,600,000.

But it must be added, that this total gain is far below what it ought to have been, owing to the extraordinary backwardness of the civil authorities to levy the water-rates. Most of the land had the water several years before the water-rates were levied; large tracts paid none for ten years. In the Administration Report, for 1860-1, it is stated, para. 132: "A proposal for the settlement of the Western Delta" (the sub-collectorate) "was submitted on 27th February last; "it results in a large annual income."

“£35,000; this arises from no adequate returns having been hitherto levied from the anicut irrigation in this part of the District.” Some of this land had had water about ten years. About £200,000 had been thus lost in this tract alone. The Sub-Collector had taken upon himself, without authority, to guarantee that no rates should be levied till a survey was made.

I should think, in the whole Delta, fully half a million was thus lost, without any cause or authority whatever; and at this moment nothing like the whole amount of water-rates is levied. The total area of land provided for is much above a million acres, though for the want of the petty distribution Works, the water has, I believe, reached only 700,000 or 800,000 acres. The water-rate is 6s. on rice land, and 4s. on a second crop of other grains, the latter requiring about a quarter as much water as rice.

The ultimate water-rate ought to be, at

least, on one million acres of rice, at 6s.	£300,000
On three-quarter ditto of dry crops, 4s. ...	150,000
	<hr/>
	450,000
Previous Revenue, deducting for partial	
Irrigation	200,000
Add for probable increase in other taxes ...	100,000
	<hr/>
	£750,000

The increase of revenue would then be £530,000, or above 100 per cent on the capital.

That this expectation is not at all too great is shown by the present revenue of Tanjore (£630,000), a similar district, but with much less natural advantages,

and with a far inferior system of Works, especially without 1,000 miles of navigation, which Godavery will have.' This rate of 6s. for rice was fixed when rice in the husk cost 75 rupees a garce of 7,200 lbs., or $\frac{1}{4}$ d. a lb.; it was about 135 rupees by the last Returns, or nearly double. Yet no change has been made in the water-rate. Taking the average crop at 1,800 lbs., the value was then 37s. 6d., so that the water-rate was 16 per cent. on the crop; and it is now only about 9 per cent.

The increase in value of crop, compared with the former precarious crop, was about 30s.; it is now about £3; so that the cultivators gain about £2 10s. per acre clear without any share in the cost of the Works, and with a very small expense in levelling their land, &c. Thus, the Government Returns show only a small portion of the total profits.

They may probably be estimated at present

at 700,000 acres of rice, at £3	£2,100,000
And 500,000 acres of dry grains, at £1 10s.	750,000

Probable increased value of crop £2,850,000

And this is besides 700 or 800 miles of water communication, conveying, all the year round, at about a farthing to one half-penny per ton per mile, while before they had not even common roads, but only a very partial, imperfect, and occasional river transit. The last return of traffic on the main canal was 5,250 boats (besides rafts) in three months, or at the rate of 21,000 per annum, from twenty-five tons downwards, averaging, perhaps twelve tons, but this included passenger boats.

To show how this great increase of value is obtained by another simple statement—

The total cost of the Works, when the whole area of about a million acres is irrigated, will be about			£500,000
Capital per acre			£0 10 0
The increased value on the rice crop per acre			2 10 0
Second crop of dry grain, about			1 0 0
Annual increase			£3 10 0
or seven times the capital, besides the water-carriage.			

There cannot be any essential error in this calculation of the comparative *cost* and *value* of water in this case, and it abundantly accounts for the large returns.

The total quantity of water distributed is as follows : The supply in the river is sufficient to keep the channels full from the middle of June till the middle of December, or for six months, and they can carry about one and a quarter million cubic yards per hour ; during the other six months the quantity gradually diminishes to about 300,000.

The quantity will therefore be during the Monsoon months		Million	Million cubic yards.
... ..		$1\frac{1}{4} \times 24 \times 180$	$= 5,400$
During the other months		$\frac{1}{2} \times 24 \times 180$	$= 2,160$
Total			7,560
which, divided for a capital of £450,000,* will be			

* The whole capital mentioned before is for the whole district, including the tracts above the Delta ; that expended within the Delta

17,000 cubic yards per £1 of capital ; or, allowing 8 per cent. for interest and management, &c., 200,000 cubic yards for £1 annually. The natives used to water their sugar, &c., by raising it at about £1 for 4,000 cubic yards, on which there was, of course, a profit ; and the water is, therefore, distributed by the canals at one-fiftieth of that cost, besides providing water carriage, by which also we see how vast the profits must necessarily be from such works. The canals will, I believe, be enlarged to carry one and a half million cubic yards. The next point is, how is this water used ? We usually reckon 6,000 cubic yards of water, including much waste, for an acre of rice, and 1,500 for dry grains, so that—

700,000 acres of rice would consume,	Million cubic yards.
at 6,000	4,200
And 500,000 acres of dry grains	
would consume, at 1,500 ...	750
	<hr/>
	4,950
	<hr/>
Total in canals... ..	7,560
	<hr/>
Not used	2,610

Only two-thirds of the water admitted is thus accounted for, so that there is a wide margin for extended cultivation beyond what I have supposed at present.

The total area of one million acres of	Million cubic yards.
rice would require	6,000
And one million of dry grains would require	1,500
	<hr/>
	7,500

So that there seems to be enough, if the waste is not excessive, for two crops on the whole area already, and there is also a large allowance to be made for the local rains; they are, however, now cultivating a great extent of second crop of rice in the dry season, and this I suppose might extend over the greater part of the Delta, greatly increasing the revenue but requiring stored water for the dry season.

We have thus the following results as proofs of the effect of irrigation and navigation in India:—

The revenue of a district has been doubled without any new taxes.

Its produce has been at least trebled.

The money expended has been repaid into the Treasury, and much more, from the very first.

The lowest net surplus, at the end of every year after the first four, was £46,000.

The total gain of revenue in one district out of the 130 districts of India, has been just a million over and above all that has been expended.

The average annual net profit from the very first has been 42 per cent.

The total capital expended on the *Delta Works* has been about £450,000 up to this time.

The total annual expense at 8 per cent. for interest and repairs, is therefore £36,000.

The capital expended per acre is 10s., which includes irrigation and navigation.

The increase of produce for one crop is about £2 10s., and for two crops about £4 per acre.

The capital expended is also £1 per 17,000 cubic yards of water.

And the annual charges at 8 per cent. for interest and repairs, £1 per 200,000 cubic yards.

The former price paid for raising water, profitably from wells, was £1 per 4,000 cubic yards, or 50 times the present cost.

The quantity of water required for a rice crop is at most 6,000 cubic yards, so that the *actual cost* of water per acre of rice is 8d.

The increase of revenue is £210,000 per annum.

The land irrigated for rice is, so far as my information goes, about 700,000 acres, besides several hundred thousand with a second crop of rice and dry grains.

The length of navigable canal and river is about 700 miles.

The cost of transit is per mile, from $\frac{1}{4}$ d. to $\frac{1}{2}$ d. per ton, and one-sixteenth of a penny for passengers.

The number of boats passing the main canal is 20,000 per annum, besides rafts.

The exports have increased from £60,000 to from £350,000 to £500,000.

The canal connects the port* with the Godavery, by which line the boats can pass in the Monsoon 350 miles; and with the Kistnah by which line they can pass along 180 miles from the port.

The total area to be irrigated is much above a million acres for two crops; the length of navigation will then be about 1,000 miles, besides the main rivers. The total value of produce will then be at least five millions sterling.

* The port of Coringa; a good port now, capable of receiving vessels of 1200 tons, and susceptible of great improvement at a moderate cost. See Captain Haig's evidence before the Colonization Committee in 1858.

The total capital for this will be half a million.

The cost of storing water to keep the channel full throughout the year, providing for an entire second crop of rice would be about £400,000.

This would at the same time greatly improve the navigation of several hundred miles of river, and be a great security against floods in the Delta.

The Madras Government has repeatedly borne witness to the success of these works. In its Administration Report for 1860-1, it says:—

“The increasing prosperity of the district is most
“vividly marked in every way.”

“The exports this year are the highest yet known,
“£500,000, besides treasure.” “The import
“of treasure was £190,000, besides Accountant-Gen-
“eral’s bills for £207,000.”

“The increase of passenger boats shows most remark-
“ably the value set upon cheap locomotion. The
“number passing along these canals was in 1843-44,
“995, in the past year it was 7,500.” (It
was 10,400 in 1863-64, passing through the heads of
the canals alone, besides vast numbers passing up and
down the different branches). The report continues:—

“The present state of the district compared with its
“state before the improvements may be briefly summed
“up as follows: the revenue has been doubled—the
“goods traffic increased thirty-fold—the passenger
“traffic seven-fold—the exports twelve-fold.”

And the facts were so notorious that the Madras Government has repeatedly urged that a specific policy should be based upon them. Thus, in a dispatch dated May 15, 1858, it starts with the assumption: “Consider-

“considerable and often immense” And it goes on to say: “The Government express their strong, “unanimous and earnest advocacy that all irrigation “works which on a comprehensive view of the wants “of the country may be deemed necessary to develop “its undoubtedly great resources, be commenced at “once boldly and on a large scale, be pushed forward “throughout all times and under all circumstances, and “be looked on, and practically treated, as in fact they “really are, as the most economical, because the most “profitable, undertakings in which the Government “can possibly engage. It is needless now again to “bring forward the innumerable instances in which “money has, in this Presidency, been most advantage- “ously invested in Irrigation Works. The proceedings “of Government have, *in this respect, been only too “desultory and too vacillating, and it is confidently asserted “that India could be placed in a position to pay all her own “expenses and gradually discharge her debt, far more “readily and speedily by a judicious expenditure, than by “any scheme of retrenchment and reduction.”*

On a subsequent occasion, the Governor of Madras, then Sir Charles Trevelyan, said that expenditure on Irrigation Works was “like sowing gold.”

Last year, the Governor of Madras, Sir William Denison, an Engineer Officer, reiterated the advice given by the Madras Public Works Commissioners* in 1852, to borrow money for these works—“works,” said Sir William,† “*which are sure to repay a large “interest upon the money expended upon them;*” and

* Mr. Bourdillon and General Balfour, C.B.

† See a long extract from Sir William Denison’s Minute, published in the *Times* of April 19th, 1865, in a “Review of the Ganges Canal.”

which, the Commissioners had said, "might be largely formed to yield 30, 40, 60, and even 100 per cent. net annual profit," while the funds to construct them might be borrowed at 5 per cent! .

Moreover, the principle of borrowing for these works has not merely been recommended by the Madras Government; it was sanctioned by a speech of Lord Stanley's in 1857, and by a formal dispatch of Sir Charles Wood's on the 8th of August, 1864.

And besides the alternative of borrowing, another mode of constructing these works has been recommended by equally high authority. The late Lord Canning, at the suggestion of Lord Stanley, had settled the policy of inviting private enterprise to undertake them, on the principle of dividing the surplus profits with the Government, in acknowledgment of its proprietary right to the waters, after allowing a liberal maximum of interest* before this division of profits, to the Joint Stock Companies which might be formed for such investments.

Lord Canning had the satisfaction of seeing one such Company start without a guarantee (the evils of the guarantee system in India were described in very strong terms by Lord Canning's Government); and Lord Canning and his Council declared that a great scheme for irrigating Behar, was "one of those of all others in India to which private capital should be invited."

* Lord Canning proposed a maximum interest, before division of surplus profits, at 20 per cent.; but this is now considered too much. It would probably be satisfactory, and certainly fairer for both parties, if the Government share began with a twentieth of the surplus profits after 10 per cent., and increased at the rate of a twentieth for every one per cent. above 10, until it reached an equal division of the surplus profits at 20 per cent.

The reader might therefore suppose that at last these works were really being taken up in earnest, and that by the concurrent means of Government loans and private investments, India was in a fair way of having one or two hundred millions spent on such enormously profitable investments as these irrigation works! especially he might suppose that at least the offer of a private Company, four years ago, to irrigate Behar, had been accepted; and that at any rate Behar could not be at this moment suffering all the agonies of famine, because no irrigation had been attempted either by public loan or private investment, and the Government had done nothing but retrograde since Lord Canning's time? I am sorry to say that if the reader did suppose this, he would be quite mistaken, as I must proceed to show.

END OF PART I.

APPENDIX.

It may be as well to add a brief statement of the profits of the Kistnah Irrigation Works: premising that Kistnah district is formed of the two districts of Guntoor and Masulipatam, excepting a tract transferred to the Godavery, which at that time yielded, I believe, a revenue of about £40,000 a year.

	Per Annum.
Average of the two districts now forming Kistnah district from 1847 to 1851.....	£308,000
Deduct for tract transferred to Godavery	40,000
	<hr/>
Before Irrigation.....	268,000
Collections of Kistnah district, 1863-64	420,000
	<hr/>
Increase since Irrigation.....	£152,000
Or 55 per cent.	

An eye-witness of the famine in this district in 1853, Mr. Lushington, Collector of Masulipatam, gave the following striking evidence of its condition then, as compared to the irrigated district in its neighbourhood: *

“No estimate of the quantities of food which have been produced through irrigation, no mere return of increase of revenue realised in an irrigated district in a year when such heavy remissions of taxes have been found necessary in other less favoured tracts, can convey any idea of the benefit which has accrued both to the Government and the people at all to be compared with that derived from actual observation of the effects in travelling through the district. No one could have witnessed as I did, the wretched condition of the people and crops on the Kistnah side of the district, the difficulty of obtaining even the smallest supply of only moderately pure water, and then have passed to the Godavery side, and witnessed with delight the contrast, the abundance of pure water, the splendid crops, and the comfort of the people, without being sensible that no figures can at all convey a true idea of the priceless blessing which the waters of the Godavery brought by means of the weir and channels through such an extent of the Delta, have conferred upon the people. In May I was encamped at Avenguddah, on the banks of a large branch of the Kistnah, then a sheet of sand: the cattle were dying of starvation in numbers; no signs of vegetation were apparent, the water was wretched, and I hope I may never see again so much poverty and wretchedness. The month of June was passed by me at Akeed, more than 30 miles from the nearest point of the Godavery, but there water and forage were abundant. The water of the Godavery, which had passed through the head-sluice more than 50 miles up the channel, flowed past my tent, and numerous boats laden with the produce of the neighbouring lands, daily passed to and fro.”

* See evidence of Captain Haig, before Committee of House of Commons, March 31, 1859.

RESULTS OF IRRIGATION WORKS, &c.

PART II.

NEARLY eight years have passed since the Madras Government uttered that manly protest which I have quoted against the neglect of irrigation works; and fourteen years since the same protest was made by the Madras Public Works Commissioners (on both occasions the Government and its officers speaking from personal knowledge of the profits of such works). Again and again has the Madras Government published authentic official reports of the "considerable and often immense" profits of such works; yet to this day no ruler of India has arisen who could grasp the plain and simple idea of developing the resources of the country: and India has had three eminent financiers, not one of whom could grapple with this grand point, but who all three occupied themselves with comparatively insignificant and petty details which could not materially affect the question, and thus left India still without any real and effective reformation of its finances, without protection from famines, without cheap produce or cheap transit, without any foundation laid for paying off its debt of about £200,000,000 (including the Railway debt), without any surplus revenue for education, but with its cruel and irritating Salt Tax, its heavy tax on justice, and others; while, had the remaining 130

districts been improved on the same principle as Godavery district, had they been enabled to pay only half as much additional revenue, which they might easily be made to do on the average with the utmost certainty, there would have been a clear addition to the national income from such improvements of £13,000,000 sterling a year—enough to provide for every want of the public service; while the simultaneous result of the operation would have placed the whole of the productions of India within reach of the ports, *at a practicable cost in carriage*, so as not only to enrich the people of India beyond calculation, but to supply England with a profusion of cheap raw material and with an unbounded market for her manufactures.

Yet to this day only a mere fraction of such improvements has been undertaken, and that, as Colonel Baird Smith observed, only in consequence of fearful and reiterated famines in every case, implying that it had always required a heavy loss of revenue, as well as the wholesale ruin and death of its subjects, to force the Government to undertake the construction of such Works, in the few instances that it has done so; although it should be remembered that irrigation works require no long locking-up of capital, but begin to yield a good interest, sometimes, as in the Godavery district, from the very *first* year, always in about two years from their commencement, if projected on sound principles.

A mere fraction has been undertaken! For instance, out of the 509,000,000 of acres in British India, scarcely 9,000,000, or one-fiftieth part, are yet in a course of being supplied with the improvements which are required to develop the resources of the country; while

probably full 300,000,000 of acres are susceptible of them, and at least 150,000,000 of acres might be supplied with irrigation and navigation (cheap transit) more easily than the Godavery district; and if only half that quantity, or 75,000,000 acres, were so supplied, the profit, at the same low rates as those charged for irrigation in Madras, would be thirty-seven and a half millions sterling a year, or an amount about equal to the whole net revenue of India at the present time!

And not only does the Government oppose the utmost possible degree of passive resistance to the construction of such works by its own resources and credit, but it has actually receded from the liberal and statesmanlike policy which induced Lord Canning's Government to welcome and invite the co-operation of private enterprise and capital in this beneficent enterprise—of which the consequence has been another disastrous famine in the fine province of Behar! Four years ago Lord Canning's Government encouraged the projects of private enterprise to supply Oude and Behar with irrigation and navigation (cheap transit); his Government actually requested the East India Irrigation and Canal Company to take up the Behar scheme, declaring this project to be "one of those of all others in India to which private capital should be invited;" and had the Company been allowed to go to work, it would by this time have been in a position to relieve Behar, because with less than two years' work it has begun to supply water in Orissa, where the scarcity was felt this season, as well as in Behar; yet because the Government subsequently abandoned Lord Canning's policy, and decided that such works should not be entrusted to private agency, it has fenced with the

above. Company for four years, it has declined its aid and done nothing itself, and therefore Behar has once more suffered the agony and ruin of a famine, and is even now suffering from it.

And the reasons given by the Government for their decision—that such works should not be entrusted to private agency—are such as literally will not bear a moment's scrutiny. The assertion that the Ryots would be left “at the mercy of commercial companies, intent only on profit,” is flatly contradicted by the terms of the Government contract with such companies; which not only give the Government an effective control over every single operation of the Companies, but even forbid the Companies to deal with the Ryots at all!—only allowing them to sell their water to the Government officers, who are themselves to retail it to the Ryots, as they do now in the irrigated districts. Moreover, the supposed danger of allowing Irrigation Companies to deal directly with the Ryots for fear they should oppress them, is met by the following curious fact, that in the only two districts where such companies have been allowed to construct Irrigation Works, the local Government officers have represented that the Companies' servants were so universally liked and trusted by the natives, that it would be much better to allow these Companies' servants to arrange direct with the Ryots for the sale of water, as they would be sure to give more satisfaction to the people than the Government officers could do. Such is the testimony of these very officers themselves! Again, I have before me an article of one of the leading native journals, ridiculing, as the extreme of absurdity, the Government's notion of protecting the people

from such Companies, denouncing the Government's "anxiety lest independent capitalists ruffle the smooth "slavery of its Ryot tenant;" declaring that British rule has for years been destroying every spark of native independence, and "sinking the people into a helplessness in the smallest concerns of life, which, to those "who remember better times, seems a puzzle;" whereas, with an honest Government for arbiter between English speculators and the people, this writer would welcome a conflict of interests between such classes as an earnest of a better state of things coming to birth, an escape from the sickening stagnation of native society; and he adds, that only independent capital and enterprise, coming between the Government and the Ryots, can stop the decay of native society, sow the seeds of better life, rouse the sleeping energy of ages, and realize his hopes "of a people independent, in "their prosperity, of their rulers, and asserting their "own private rights without fear, openly and honestly, "in the courts of the land."

The above explanation shows that the ostensible reasons of the Government for deciding that Irrigation Works shall not be intrusted to private agency, have really no foundation whatever, for it is clear from the above—1st, that as a matter of fact the Ryots are not left "at the mercy of commercial companies intent only on profit;" 2nd, that the local Government officers, judging from what is passing under their own eyes, think they might be so with perfect safety, and with more satisfaction to themselves; and 3rd, that some of the most intelligent natives wish they were so, and say boldly that a conflict of interest between capital and labour is required to regenerate India, and "the

“less the Government comes in contact with the
“millions of the land, the better for all parties!”

Surely, then, with every conceivable motive of policy, justice, humanity, and financial safety urging them to construct the works required to develop the resources of India, it is shocking to see the Government still oppose the same immovable passive resistance to the prosecution of this beneficent enterprise, which, for the last thirty years, in spite of a continued battle, has prevented its effectual development, and confined it to a mere fraction of the country, not even permitting it there, as Colonel Baird Smith observed, until forced by repeated famines to undertake a few local improvements.

It is shocking to think that a civilized Christian Government should require the pressure of many more famines, involving the loss of hundreds of thousands of human lives, and millions of money, as well as the utter destruction of cattle and agricultural capital over immense districts (a destruction irreparable for ten or twenty years together) to force it to extend gradually to the rest of India those works of irrigation and navigation which are so enormously profitable to itself, as I have shown, as well as to the people whom it has undertaken to govern.

I hope it will not be so, and there are reasons for believing that it will not be so; for it is notorious that during the last ten or twelve years the principal ground of the Government's opposition to the extension of irrigation and navigation generally throughout the country has been a disbelief in the remunerative character of such works, caused by the utter failure, in this respect, of the Ganges Canal. It has, however,

now been proved by official investigations, that the exceptional failure in this case was entirely due to fundamental errors in the projection and execution of the work, errors which were carefully avoided in all the great works of Madras, so that it is now certain that if the Ganges Canal had been projected and executed on the same principles of construction as those adopted in Madras, it would long ere now have been yielding enormous profits to the State, like the Madras works, and it may even now be rendered a highly remunerative work in spite of the extravagant and unheard of amount of capital invested in it, if it be remodelled on Madras principles,—though not otherwise! If the Government persist in remodelling it on different principles, in spite of the emphatic warnings which have been given them by myself, and by the public opinion of India, as expressed in the local journals, the Ganges Canal will continue to be a financial failure, though a failure of this sort, deliberately incurred by the Government, cannot be a fair argument against the remunerative character of all works of irrigation and navigation constructed on sound principles; that is, on the very different principles from those of the Bengal Engineers, which have been tested by long experience in Madras, and have proved invariably and most wonderfully successful, by the admission of the Government itself.

I hope, therefore, that the Government, supported and impelled by public opinion, will resolve at length to act on the principle laid down eight years ago by the Local Government of Madras, viz., that the works of irrigation and navigation, or cheap transit, necessary to develope the resources of India, should be “com-

“menced at once, boldly, and on a large scale, and
 “pushed forward throughout all times and under all
 “circumstances,” as “the most economical, because the
 “most profitable undertakings in which the Govern-
 “ment can possibly engage.”

Three things would be necessary to the carrying out of such a principle in India: 1st, that the Government should return to Lord Canning's policy of inviting the boundless resources of private enterprise and capital to aid the State by undertaking works of irrigation and navigation; 2nd, that the ruinous and unfair system of constructing remunerative public works with the precarious supplies of current revenue be finally renounced in practice, as it has long been condemned in theory; 3rdly, that the Department of Public Works should be reorganised on the principles laid down in Mr. Dickinson's “Letter to Lord Stanley,” in 1863, as abridged by him from the 2nd Report of the Madras Public Works Commissioners in 1853; so as to insure the right application of, and due accounting for, the funds expended by the Government on “works of internal
 “improvement.”

Trusting that the above principle will at length be heartily adopted by Her Majesty's Government, after having had such ample experience of the “Results of Irrigation Works,” I will only add a few words with respect to the extension of Irrigation and Navigation generally throughout India.

It must be observed that the upland districts could not be improved so cheaply as the Delta countries, and that, partly from a great rise in the price of produce and labour, partly from topographical peculiarities and different degrees of density in the population of various

localities, there will be considerable difference in the cost of works in many districts of India, and an average increase of, at least three times the former cost in Madras, exclusive of the expense of storing water. On the other hand, by far the greater part of the present population occupy tracts as favourable as the Delta of the Godavery, or more so. All the great Delta tracts of the Vygār, Cauvery, Pennair, Kistnah, Godavery, Mahanuddy, Brahminy, and the whole plain of the Ganges from Hurdwur to the sea, are of this kind. Indeed the latter is far more favourable than the Madras Deltas. So that the remaining populous parts of the country, excepting a small portion, could be irrigated and supplied with steam navigation at an average rate of about £1 10s. per acre *at present prices*. At least five-sixths of the population, or 150,000,000, occupy lands of the above class, and average about 300 inhabitants to the square mile, making 500,000 square miles, which, at 500 cultivated acres per square mile, would be 250,000,000 acres; and this, at £1 10s., would require a capital of £395,000,000 sterling: an expenditure which would enable the country to bear fully 500,000,000 of people, or above three times its present population. If the work were carried on at the rate of £40,000 a year for each district, or £5,000,000 a year in all, all the great lines of cheap communication might be opened in five years, besides giving 17,000,000 of acres of irrigation; and no country in the world ever underwent such a transformation as this would make in India.

POSTSCRIPT.—I forgot to mention one of the advantages of entrusting hydraulic works in India to private

enterprise, viz., that it would prevent the present well-founded complaints of the impossibility of obtaining redress for injuries inflicted on the native landholders during the construction of public works by Government servants. Where the Government is judge in its own cause, and there is no appeal to an impartial tribunal, I have sometimes found it impossible to get parties paid for their land which was appropriated for public works. In the case of private Companies there would be an appeal to such a tribunal, and no ryot could have his land taken, or be otherwise injured, without the certainty of getting compensation.

A LETTER

(Dated 12th November, 1867,)

ADDRESSED TO THE

Government of India

ON

IRRIGATION AND NAVIGATION,

WITH REFERENCE TO THE

GANGES CANAL CONTROVERSY.

BY

LIEUTENANT-GENERAL SIR A. COTTON.

DUBLIN:

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1867.

A
LETTER FROM SIR ARTHUR COTTON,

LIEUTENANT-GENERAL R. E. MADRAS,

TO THE
SECRETARY TO THE GOVERNMENT OF INDIA.
(*Irrigation Department.*)

Sir,

As I have not yet had the honour of any remarks on the subject of my letter in reply to the Ganges Canal Commission Report, a copy of which I submitted to you, I beg respectfully to bring the matter again to the notice of H. E. the Viceroy.

I feel assured that he will see that justice to me requires that some notice should be taken of this communication, to say nothing of the incalculable importance of this controversy in its bearing upon the welfare of all India; for it will certainly be allowed that the whole question of irrigation and navigation for all India now hangs upon this one point, viz., the real causes of the failure hitherto of this great work. If it is owing to causes which can easily be avoided in future projects, and but for which it would have been an immense success like the Madras works, the grand obstacle to general irrigation and navigation, with all their incalculable results, is removed, and not a single objection remains to a complete system of hydraulic works similar to what has been done in the matter of railways.

But, waving this part of the question, I put my present application mainly upon the ground of simple justice to myself.

It cannot be denied that I was not allowed to have any voice at all in the nominal investigation that was instituted under this Commission. I was neither consulted respecting the Commissioners, nor was any person examined on my side of the question. No opportunity whatever was given me of being heard, either in person or through any one deputed or approved by me. Had there been, it is impossible the Commission could have fallen into the gross mistakes they have made.

The Government of India have given their official sanction to

this *ex parte* Report, and I must respectfully urge that the least that justice demands now is that my reply should be acknowledged, and the judgment of Government passed upon it, as it was on the Report of my opponents, before I was heard.

The leading points in this discussion lie in a nutshell, and are such that it is impossible but that the Government can certainly come to some definite conclusion upon them. They are not obscure professional points upon which it can be said that non-professional men cannot pass judgment.

I will here have the honour to recapitulate two or three of the leading points upon which I most earnestly request the decision of Government.

1st. In Captain Crofton's Report he charged me with proposing a new head to the canal, which would involve a cutting of ninety feet and an outlay of two and a half millions sterling; and this shameful charge, for which there was not a shadow of ground in anything I had written, received the official sanction of the Government (without even adding Captain Crofton's own acknowledgment of the complete reply to that absurd idea contained in a letter some person had written to the *Times*) in a despatch to the Secretary of State.

The Commissioners, in their Report, estimate that such a new head can be carried out for £700,000, with a cutting of thirty-six feet to carry 80,000 cubic yards per hour (640 cubic feet per second, one-seventh more than the present canal carries; and, with the latter 300,000 cubic yards, one-third more than Captain Crofton's "re-modelled" canal is calculated to carry.

Thus the Commissioners themselves completely refute Captain Crofton's charge, by estimating that the quantity of water now carried could be transmitted by a new head below the hills for about £600,000, or one-fourth of Captain Crofton's estimate; and with a cutting of thirty-six feet instead of ninety. I show in my reply that this line proposed by the Commissioners is, like Captain Crofton's, quite a false line; and that even with the levels we now have, the new head would really cost only about £150,000, with a cutting of say twenty feet, against Captain Crofton's two and a half millions, and ninety feet; and there can be little doubt but that with a more careful examination of the ground, and exact calculations, the cost would be below this.

Now I must respectfully ask whether it would not be just in the Government officials to exonerate me from the gross charge made

by Captain Crofton, as they have officially sanctioned it before enquiry?

2nd. The Commissioners estimate a weir across the Ganges below the hills at £450,000, for a river carrying thirty-five million cubic yards per hour, or £13,000 per million cubic yards of discharge. I gave the actual cost of eight much larger weirs already in operation in precisely similar sandy rivers, which afford an average of £500 per million cubic yards, so that the Commissioners' rate is actually *twenty-six times that which such works have been proved to cost*. Now what would be said if an engineer were to send in a project for a railway on the plains of the Ganges, roughly estimating it at £520,000 a mile, twenty-six times the average cost of those already constructed there, which is £20,000 a mile. There is no difference whatever between this river and the others as to their nature, excepting that it is in comparison quite insignificant in volume and depth. The extreme depth in this case from the bottom of a hole in the bed to the top of the flood is only twenty-one feet; that of one of the others, the Kistnah, is seventy feet. The only difference the Commissioners state is in the size of the sand, as if it would make an appreciable difference in the cost of such a work whether the sand was fine or coarse.

I urge this point, too, as one of which non-professional men are perfectly competent to judge; and it is impossible but that any one must see that such an estimate stamps the whole Report which contains it as utterly absurd and worthless. No men could make such a mistake unless they were under the influence of an overwhelming bias, for I cannot of course suppose that they gave a wilfully false estimate, as I have been accused of doing by two of my opponents officially and publicly.

3rd. In Sir Proby Cautly's papers on this proposition for a new head (see p. 79 to 83 of his "Disquisition,") he says that a weir here "would cost more than all the works from Hurdwar to Nawarree" (a million sterling), "that it would inundate eighty square miles, destroying many cultivated villages, desolating the country with fever, &c." Not a word of all this is found in the Commissioners' Report, though certainly from the whole tenor of it, it is evident that they would gladly have supported Sir Proby in this, if they could.

In these things I cannot but observe here how impossible it would have been for a just and impartial Commission to have thus overthrown my opponents, without an honest acknowledgment that in these things I had been grossly misrepresented, and that their examination thus fully supported in the main my view of the case.

4th. In my paper I give the actual increase of revenue, &c. due to the works in Madras, in figures, showing an increase of revenue in Godavery of £270,000 a year, by an expenditure of £500,000. The Commissioners write pages saying that they consider the profits to have been greatly exaggerated, &c. but not one word do they write in refutation of these plain figures. If these returns were all false, of course they could be shewn to be so; but what are we to think of a denial which does not contain a single figure, and which even carefully avoids the mention of the actual returns of revenue, &c. and any opinion as to what the actual profits were? Did the Commissioners think the profits were one-half or one-fourth of those stated. They could not give a figure, or hazard any definite opinion on the subject. The fact was, there was the money in the treasury, and there was no possibility of getting rid of it; and therefore the only possible way to deal with the case, in order to avoid acknowledging the reality of the profits, was to say, "We don't think, &c."

By referring to the following figured statements, it will be seen at once why nothing is said in refutation of them, and why no figures at all are given in the Commissioners' Report, in connection with this point, of the profits on the Madras works.

			Ganges. £	Godavery. £
Cost of Works to present time	...	...	2,100,000	500,000
Interest, without allowing for compound interest	...	...	900,000	.
Total capital	...	...	3,000,000	500,000
Receipts last year	...	...	134,000	
Supposed increase of land tax	...	...	30,000	
<i>Total Receipts</i>			164,000	
Increase of revenue	...	...	...	270,000
Per-centage of gross receipts on capital	...	...	5½	54
Deduct expenses	...	£60,000	2	
For the Godavery about	...	£15,000		3
Net profit per cent	...	...	3½	51

And to show how much of this 51 per cent. on the Godavery is due to the works, I compare it with the progress of the adjoining districts.

Average revenue of Vizagapatam, Vellore, Cuddapah, Bellary, and Kurnool for 5 years, to 1846	£	1,059,000
Ditto for 1864-'6	...	1,215,000
Increase	...	156,000
		or 15 per cent.

But much of this also is due to improved irrigation.

Again, average revenue of Godavery before 1846	...	225,000
Revenue of 1865-'6	...	492,000
Increase in Godavery in same period	...	267,000
		or 120 per cent.

Allowing only one-third of the increase in the other districts to be due to improved irrigation, it leaves an increase there of only 10 per cent. against 120 per cent. in Godavery, so that we cannot be wrong in considering that 11-12ths of the increase there is due to the works. Again, the cost of irrigating 800,000 acres in Godwarry is £500,000, or 12s. an acre, and the actual water rent now paid on one crop is eight shillings an acre, which is 66 per cent.

And as with the revenues, so with the exports and internal traffic.

Average exports by sea before 1846	...	£57,000
Exports of 1865-'6	...	890,000
Increase	...	£833,000
		or 1500 per cent.

Number of boats on main canal in 1851, the first year,	1,000
Ditto in 3 months of 1865	5,250
Which would give per annum	21,000

And these probably double the size of the former ones.

Increase, about 42-fold.

If seven commissions were appointed, they could not get rid of such plain figures as these.

5th. The Commission themselves have shewn that it was quite practicable to lead off water from below the hills from both the Jumna and the Ganges, and that by their own estimates, at much less cost (about half a million less) than by the present head; so that

they fully support my main point, that the great mistake was going up into the hills for the water. Ought not the Commissioners to have honestly and broadly stated that they considered that I was perfectly right in the main point of all in the controversy? The saving of half a million in leading the water from the river to the ridge of the Doab would alone, if there had been no other saving from avoiding other great mistakes, have totally altered the results, both shortening the time of construction, and diminishing the capital and the accumulated interest; so that instead of yielding $3\frac{1}{2}$ per cent. net after 20 years, it would have yielded, if this mistake alone had been avoided, *and taking the Commissioners' own estimates*, eight or ten per cent. five years ago. And, taking the real cost of the proposed head at £100,000, which is the utmost it would have cost twenty years ago, there would have been a saving of nearly a million in cost alone, besides interest, and about half the time; so that the works would have been yielding at least twelve per cent. ten years ago—so ruinous was this fundamental mistake of going up into the intricate hill-country for the water, when it could be had, even by the Commissioners' own showing, from a part of the river clear of all the difficulties. It is of the utmost importance to keep this great point in view, because it proves, even upon the finding of a hostile commission, that there is not a vestige of ground of doubt about the profits on irrigation generally to be drawn from the Ganges Canal, but quite the contrary.

6th. I have thus satisfactorily established, with the concurrence of the Commissioners, that this work, if tolerably correctly projected, would have been a magnificent success in point of direct return, as well as of other things, instead of a grievous failure; and that it would have been the strongest possible support of irrigation and navigation generally, instead of the grand obstacle to it, as it now is.

7th. The last point I beg here to bring before the Government is the essential one of transit generally. On this point the Commissioners and myself are directly at issue; and I must insist upon it, that upon which is right must depend in a fundamental way the future management of India in respect of public works. The Commissioners' ideas are shewn in the short remarks they make on my urging the extension of the navigation to Allahabad. They say, that "no part of India is better provided in proportion to its area with the means of transport." In the first place, what has this to do with the matter? Upon the same grounds, if it were true, no

part of India ought to be provided with irrigation, or education, or any thing else. What can be the necessity for preventing famine in future in Orissa, when millions have died of it in every other part of the country? Again, it is true only one per cent. can read and write in Bengal, but what necessity can there be for education there, when all the rest of the population are in the same dreadful state of ignorance? Who cannot see the fallacy of such arguing as this? But, secondly, this quotation, from the Commissioners' reports shews that they think a railway and a common road, which carry perhaps 100,000 tons a year at from 1d. to 6d. a mile, is just the same thing as a steam-boat canal to carry millions of tons at 1-10th or 1-20th of a penny. The quotation shews that the Commissioners have never given the subject of transit one careful thought. The carriage of 100,000 tons a year, at an average cost of 3d. a ton, can scarcely have an appreciable effect on the prosperity of this immense population; while the carriage of two or three millions of tons at 1-15th of a penny would give the most astonishing impulse to the life of the whole country. Cotton is now carried at $4\frac{1}{2}$ d. a ton a mile, or £18 from Delhi to Calcutta—2d. a pound—six or eight times the cost of carriage thence to England. While a Calcutta merchant is bargaining to the last moment with the owner of a vessel whether the freight to Liverpool is to be 38s. or 40s. per ton, he is submitting without a remonstrance to a charge of £18 for the inland carriage. Nothing can be more contrary to fact, than that "no part of India is better provided with the means of transport" than the Doab. The lower Ganges provides a cheap transit throughout the year (though not nearly so cheap as a steamboat canal would afford), and the consequence is that the amount of traffic is there prodigious—several million tons a year. Three million tons of boats enter and as many leave the Calcutta canal every year, so that for one ton moved in the Doab there are thirty or forty in Bengal. The Commissioners think that it is not a matter of the slightest importance whether India is provided with cheap and effective transit or not; whether, in contending with America and Egypt, Indian cotton arrives at Manchester loaded with a charge for inland transit of 2d. a lb., or 1-20th of a penny; for this is certainly the point at issue between us. Is land-carriage a *substitute* for constant effective water-carriage, or is it not? Is it the same thing whether the cost of transit is so high as to stop 19-20ths of the traffic there would be, or is it not? And whether a work *can* carry the necessary traffic of a vast and closely populated tract, or

only 1-20th or 1-50th part of it? Surely this is a real question, and not to be evaded, as is done in the Commissioners' Report.

I need not go into further detail here. I now beg to submit it to the Government of India whether it can be consistent with justice to me or for the public good, that this great question should be left undecided, without any open official declaration of the conclusions of Government on this vital question: and what they think of a Report in which a great work is estimated at twenty-six times the actual average cost of similar works; in which, on all the leading points, they really support my side of the question, without any honest acknowledgment of it; and in which they endeavour to throw a doubt upon the great profits from correctly projected irrigation works, without any attempt at a real refutation of the unquestionable figures given, and which are taken from the Government returns, or even their own statement of what the returns were.

I must also state that I have reliable information that one of the Commissioners would not subscribe to much that was in the Report; and that another, the moment he had an opportunity of obtaining any real information about such works, of which he had no previous experience, wrote to the Secretary to Government stating that had he known what he had since learned, he could not have signed the Report.

Thus this Commission consisted of a chairman personally and professionally opposed to me; three officers connected with Bengal, and therefore necessarily under local bias, two of whom have now objected to much that was in the Report; and only one who might have been unbiassed, but had not had the least experience in such great irrigation works with weirs; all of them also perfectly aware that the Government had already taken a part in favour of the local officers, so that they could not shew any inclination to favour my side of the question, without feeling that they were acting in opposition to those who had appointed them, and upon whom they depended for promotion, &c. And before these not a single witness was examined on my side, and one who offered to answer any questions was refused.

Further, can it be for the honour of the Government that a document should be printed professing on its title page, "to be convened to decide upon the propriety * * * of stopping the progress of the remodelling of the canal, pending the preparation of a detached project ACCORDING TO THE VIEWS OF SIR ARTHUR COTTON, with a comparison of the cost and advantages of the two plans;" while that

officer was not heard in the matter, but all the ideas of the cost and advantages of his plan were taken from his opponents?—the actual so-called investigation being thus in direct contradiction to its professed character.

I must add that this matter cannot possibly rest here. The late famine has convinced the public in England that there is that hanging upon the correct solution of this question of irrigation and navigation in India, which is of such importance that all personal feelings and local biases must be overborne, and both sides of the question be brought fairly and honestly into the light.

The Government must have been either satisfied with my answer to the Commissioners on the leading points, or they must have considered that it left them in possession of the ground they had taken up, viz., that a work across the Ganges would cost twenty-six times the average cost of similar works already in operation, or not; that the Madras works have or have not made the large returns shewn in the figured statements; that a new head to the canal would cost two and a half millions, or £700,000, or £150,000; that it was right, or it was not, that in a professed investigation of my views neither I nor any body on my side should be heard; that that was or was not an unbiassed Commission, of whom not one honestly protested against being called upon to decide the question between Sir Proby Cautly and Captain Crofton on the one side, and myself on the other, while Captain Crofton was in constant attendance on the Commission, and actually ordered to be so, in order to “explain his views;” but I and every body on my side were excluded.

My present respectful request is that the conclusions of the Government on these points, whatever they were, may be officially stated, as the Government have before officially sanctioned the charges made against me by my opponents before inquiring.

I have the honour to be, Sir,

Your most obedient servant,

A. COTTON,

Lieut.-General R. E. Madras.

Bryansford, Castletwellan, Co. Down,

12th November, 1867.

